RESEARCH MEMORANDUM 79-3

LEVEL II

THE DEVELOPMENT AND VALIDATION OF AUDIOVISUAL SIMULATED PERFORMANCE TESTS USING 35MM SLIDES

David W. Bessemer and Ronald E. Kraemer

ARI FIELD UNIT AT FORT KNOX, KENTUCKY

U. S. Army
Research Institute for the Behavioral and Social Sciences

May 1979

79 22 5 118

Best
Available
Copy

14 ARI-RM-79-3

Army Project Number
16 2Q763731A770

Performance Oriented
Individual Skill
Development and Evaluation

9 Research Memorandum 79-3

6 THE DEVELOPMENT AND VALIDATION OF AUDIOVISUAL SIMULATED PERFORMANCE TESTS USING 35MM SLIDES.

10 David W. Bessemer and Ronald E. Kraemer

Donald M. Kristiansen, Team Chief

11 May 1979

12 132

Submitted by:
Donald F. Haggard, Chief
ARI FIELD UNIT AT FORT KNOX, KENTUCKY

Accession For	
NTIS GRA&I	☒
DDC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist.	Avail and/or special
A	

Approved by:

E. Ralph Dusek, Director
Individual Training and Performance
Research Laboratory

Joseph Zeidner, Technical Director
U.S. Army Research Institute for
the Behavioral and Social Sciences

Research Memorandums are informal reports on technical research problems. Limited distribution is made, primarily to personnel engaged in research for the Army Research Institute.

408010

FOREWORD

This research, completed by the Fort Knox Field Unit of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI), is part of an overall effort under Work Unit SIMTEST to develop a methodology for deriving valid simulated performance tests and a set of guidelines that Army item writers and test developers can use in preparing skill qualification tests (SQTs). This report describes efforts to develop an audiovisual simulated performance test using 35mm slides as the stimulus presention mode.

The impetus for the project was Human Research Need (HRN) 76-181 submitted by the Training Management Institute (TMI) of TRADOC. The project is part of Military Personnel Performance Development and Assessment (project 2Q763731A770, Program Element 637 31A, Task A). The R&D coordinator was MAJ Douglas W. Smith.

The Army Research Institute expresses appreciation to MAJ James S. Cary and SSG Herman E. Hill, 1st Training Brigade, Fort Knox, Ky., for their support and cooperation throughout the project.

JOSEPH ZEIDNER
Technical Director

SUMMARY

Military Problem

Through the creation of the Enlisted Personnel Management System (EPMS) the U.S. Army is currently replacing Military Occupational Specialty (MOS) tests with Skill Qualification Tests (SQTs). These tests will be used to validate the competence of enlisted personnel at five levels of skill within their MOS and will be made up of (a) a written component to verify a soldier's knowledge of the job, (b) a hands-on component that evaluates how well the soldier can perform the job, and (c) a performance certification component that allows the supervisor to declare how well the soldier can perform tasks not covered in the other two components.

In developing SQTs for each MOS area, the Individual Training Evaluation Directorate (ITED) responsible for the SQT system has encountered problems of high cost, difficulty in maintaining test standardization, and the fact that many critical job tasks cannot be simply translated into job performance tests. Some tasks specify terrain, equipment, or material requirements that are unavailable, and other tasks require conditions so hazardous as to preclude such testing altogether. Also, Test Development Agencies (TDA) often lack experienced and technically qualified test developers.

Objective

This research examined the feasibility of using audiovisual simulated performance tests as an alternative to hands-on performance testing. Knowledge from this effort would contribute to the data base for (a) developing the methodology for development of valid simulated performance tests, and (b) evolving a set of guidelines that can be used by Army item writers and test developers responsible for SQT development.

Approach

First, an audiovisual simulated performance test was developed for the tasks of removal, disassembly, assembly, and installation of the 105mm Main Gun (M68) breechblock mechanism. Second, a performance checklist was developed for each task to collect hands-on criterion data. Third, an interrater reliability study was conducted using the performance test criterion. Fourth, a comparison study was conducted between the simulated and actual performance tests. Fifth, based on the results of the comparison study, a methodology for development of audiovisual simulated performance tests was formulated. Sixth, based on the methodology, a shortened form of the breechblock tests was prepared and compared with hands-on performance. Seventh, a second audiovisual simulated performance test on the coaxial machine gun (M73/219) was subsequently developed by the methodology and also compared with hands-on

test performance. The latter two tasks were directed toward evaluation of aspects of the test development methodology.

Materials

The breechblock audiovisual simulated tests were based on a detailed analysis of behavioral elements required in each performance step. Test questions were related to the part, action, tool, location, and result of each step and were sequenced to maintain a sense of performance continuity in the simulated test. Response alternatives for each three-choice item were represented by black and white photographs reproduced on 35mm slides. Questions on audio tape synchronized with the slide presentation.

Short-form test versions omitted many of the items, retaining those identified as "critical" for successful task performance and intervening items required to maintain task continuity. "Critical" items were those that could involve (1) injury to personnel, (2) damage to equipment, and (3) direct impact on ultimate completion of the task.

Checklists for hands-on performance tests included the behavioral elements used as a basis for the audiovisual simulated tests. The checklist format highlighted elements corresponding to simulated test items.

Results

Critical Items. Acceptable interrater reliability was obtained with the hands-on checklist only when performance was scored as number of errors on critical items. Performance on both hands-on and audiovisual simulated tests was measured by critical item errors throughout the subsequent research. Zero critical errors was categorized as a passing score for both types of test.

Validity of Audiovisual Simulated Tests. The relationship between audiovisual simulated and hands-on test performance was high in most cases and was significant when three categories of audiovisual test performance (Pass-Borderline-Fail) were compared to pass-fail performance on the hands-on test. The only exceptions occurred when very few hands-on test failures were obtained, so that the variation in performance was artificially restricted.

Screening by Audiovisual Simulated Tests. The nature of the relationships found between audiovisual simulated and hands-on test performance indicated that the simulated test could be used to screen groups of examinees to identify qualified personnel. Examinees making no critical errors on the simulated test (Pass group) had a high probability of passing the hands-on test. Chances of passing the hands-on test declined as the number of critical errors on the simulated test increased in the Borderline and Fail groups. In general, the audiovisual simulated tests were more difficult than the corresponding hands-on test.

Using audiovisual simulated tests, a decision to pass an examinee was found to have no more risk of error than would result from use of a hands-on test. The Borderline and Fail groups on the audiovisual simulated tests were found to contain many false negatives, i.e., examinees that pass the subsequent hands-on test. Despite this fact, however, evidence was obtained that a prior audiovisual simulated test predicted subsequent hands-on performance at least as well as a prior hands-on test.

Transfer Effects. Audiovisual-simulated testing did not produce any measurable positive transfer to subsequent hands-on performance. Therefore, transfer effects could not account for the difference in difficulty between the two forms of testing. Transfer from hands-on to audiovisual-simulated test performance was obtained for one task.

Greater learning would be expected in hands-on testing resulting from sources of intrinsic feedback. Such sources are much more limited in the audiovisual simulated test, and little learning can be generally expected with such tests. In cases where it is desirable to avoid learning effects, such as repeated assessment of individual task readiness levels in units, or repeated testing to determine the time-trend of retention loss, audiovisual simulated testing may offer significant advantages. However, because of the difference in difficulty between simulated and hands-on tests, the audiovisual test will tend to underestimate actual level of hands-on performance capability.

Conclusions

1. The development of reliable and valid hands-on and simulated methods for performance testing should be based on detailed behavioral analysis and identification of performance elements critical to task performance.

2. Validated audiovisual simulation tests may be used to supplement or replace hands-on testing for low-skill procedural tasks in institutional and unit training settings.

3. Comparison of performance on audiovisual simulated tests and hands-on tests may be used to identify particular elements of skill in procedural tasks. Partial hands-on tests of skill elements may then be combined with an audiovisual simulated test of nonskill elements to form a synthetic test for the task.

4. Lack of transfer from audiovisual simulated test performance to hands-on performance suggests that the simulated tests may be useful in repeated assessment of unit readiness levels and time-trends of retention loss for individual Soldier's Manual tasks.

THE DEVELOPMENT AND VALIDATION OF AUDIOVISUAL
SIMULATED PERFORMANCE TESTS USING 35MM SLIDES

CONTENTS

CONTENTS (continued)

Page

LIST OF TABLES

CONTENTS (continued)

THE DEVELOPMENT AND VALIDATION OF AUDIOVISUAL SIMULATED PERFORMANCE TESTS USING 35MM SLIDES

INTRODUCTION

Background

Military Problem. The Enlisted Personnel Management System (EPMS) has been designed to meet Army requirements for manpower and the needs of individual soldiers for career progression. Apart from the career progression portion of the EPMS, a comprehensive testing program is included to validate the competence of enlisted men at five levels of skill. The testing program requires the replacement of paper-and-pencil MOS tests by Skills Qualification Tests (SQTs) that emphasize hands-on performance testing. The impetus for this change can be attributed to the Brown Board Study (1966), which found the Army's Enlisted Evaluation System to be inadequate to assess MOS job skills, and the establishment in 1971 of the Combat Arms Training Board (CATB) by the Board for Dynamic Training (the Gorman Board). These boards concluded that (a) paper-and-pencil tests of hands-on skills are low in validity, and (b) verbal tests are unfair for certain enlisted personnel who are highly skilled in their respective jobs but low in verbal ability.

Under the new MOS evaluation program, SQTs are being developed that are not only performance-based but also criterion-referenced. The SQTs are performance-based in that soldiers will be required to demonstrate that they can in fact perform each key task of the job, and criterion-referenced in that successful performance is based on established task standards, not on comparison with other soldiers tested. In addition to these requirements, SQTs are to be group administrable; measure the professional competence of the soldier; serve the needs of personnel management; be perceived by the soldier as fair, equitable, and relevant; and be inexpensive to develop and administer. Based on their SQT results, soldiers will be verified at their present MOS skill level (Verification Score), qualified for award of the next skill level (Qualification Score), or required to retake the SQT the following year. Failure to pass the SQT the second time, however, may result in a reduction in rank, an MOS reclassification, or the establishment of bars to reenlistment.

Research Problem. To aid in the transition to the SQT program, numerous studies of performance testing have been conducted. These efforts have included studies on task analyses, the development of performance measures, the development of performance tests, and the development of criterion-referenced tests. Despite these efforts, critical problems have surfaced. For example, Engel (1970a and b) and Engel and Rehder (1970) reviewed arguments against the use of performance tests for part or all of the MOS battery. They felt the exclusive use of performance tests would be too costly and impractical in many MOS. Occhialini (1972) also noted that performance tests are extremely difficult to prepare and administer and are of questionable validity in a variety of situations. The Individual Training Evaluation Directorate (ITED) responsible for implementing and administering the SQT system has encountered more basic problems (Osborn et al., 1977). In addition to the high cost and difficulty in maintaining standardization, many job tasks cannot be simply translated into hands-on performance tests. Some tasks specify terrain, equipment, or materiel requirements that are unavailable, and other tasks require conditions of performance that are so hazardous as to preclude such testing altogether. Other tasks contain such lengthy or transient task behaviors that adequate measurement is extremely difficult, if not impossible. Moreover, Test Development Agencies (TDA) responsible for developing the SQTs are made up of personnel who often lack the experience or qualifications needed to prepare high-quality SQTs.

Relevant Research. For the past 10 years, research scientists in the Advanced Systems Division at Wright-Patterson Air Force Base, Ohio, have also been investigating the use of formal measuring devices to ascertain the job proficiency of military personnel. Results based on an analysis of maintenance performance evaluation (Foley, 1974) confirm the findings reported by the Army's Brown Board; that is, there is little relationship between success on paper-and-pencil and theory tests and ability to perform maintenance tasks on the job. Moreover, most training programs contain subject matter unrelated to the ability of the individual to perform critical job tasks. Consequently, increased efforts were directed at replacing paper-and-pencil tests with criterion-referenced job performance tests and elimination of irrelevant course content. The Air Force, like the Army, has experienced critical problems in shifting to performance-based training and testing (Foley, 1974). Equipment, time, and personnel costs, both in training and testing, are extremely expensive.

Proposed Solutions. Reactions to the interservice problems of paper-and-pencil tests versus job performance tests have resulted in several research efforts. For example, Glaser and Klaus (1962) have suggested that proficiency measurement techniques may be loosely categorized on the basis of their remoteness from actual job performance. This remoteness may be due to differences in the (a) eliciting stimuli, (b) the behavior elicited, or (c) both stimuli and behavior. Thus, paper-and-pencil tests and actual job performance represent extremes on the remoteness continuum. Between these extremes are test situations that call for actual job performance outside the real environment or that attempt to simulate the job task while offering affective control of the factors that in "real" situations are likely to interfere with reliable and valid measurements.

As one solution, Engel and Rehder (1970) have advocated a mixture-of-measurement technique to include combining work samples, simulated tests, peer ratings, and paper-and-pencil tests. Their evidence shows that (a) paper-and-pencil tests can be used to measure cognitive items, (b) work samples or simulated tests can be used to measure manipulative items, and (c) peer ratings can be used to measure social, leadership, and overall ability.

Similarly, Osborn (1970) has suggested the development of synthetic tests, i.e., tests conceived of as job performance tests that have been degraded to some degree in the range of task elements covered or in the fidelity of stimulus/response features. The continuum is bounded by paper-and-pencil tests at one extreme and by job-sample skill tests at the other. Within this continuum, a broad range of possible testing approaches can be constructed. Recently, Osborn and Ford (1976) explored knowledge testing of low-skilled psychomotor tasks and synthetic tests of skilled psychomotor tasks with Army personnel. For psychomotor tasks, the data strongly supported the hypothesis that performance on low-skill procedural tasks is mediated by knowledge. The knowledge mediating performance, however, is not the kind usually tested in paper-and-pencil tests, but is knowledge pertaining directly to performance of the task. They also showed that the Picture Choice method of testing such knowledge demonstrated a high correlation with hands-on task performance that was relatively constant over a range of mental ability; this method is preferred by the soldiers over other methods of pictorial testing. For skilled psychomotor tasks, the studies indicated that valid test results could be obtained despite a substantial reduction in external feedback fidelity.

To develop empirically valid symbolic test substitutes for military maintenance tasks, several alternative methods have also been examined by Shriver and Foley (1974a) at various levels of sophistication. For example, the Multiple Alternative Symbolic Troubleshooting Test (MAST) (Grings, Rigney, Bond, & Summers, 1953) and the Tab Test (Crowder, Morrison, & Demaree, 1954) were studied and found to be likely candidates for performance test substitution if increased realism could be provided. At their present stage of development, however, such tests were not recommended by the authors as substitutes for hands-on testing. With these experiences, follow-on efforts were initiated to develop and validate both graphic (Shriver & Foley, 1974b) and video (Shriver, Hayes, & Hufhand, 1974) symbolic substitutes for which a job task performance test had been developed. Based on the results of these efforts, it was concluded by the authors that (a) video should not be further considered as a testing medium for performance analogues and (b) that future efforts be directed toward developing and refining graphic symbolic substitute tests.

In agreement with the results of Osborn and Ford (1976), Shriver and Foley (1974b) found that graphic tests were most valid for low-skill fixed-procedure tasks, while lack of dynamic feedback in the graphic symbolic displays created problems in branching procedure tasks, such as electronics alignment and troubleshooting. Graphic substitutes appeared to have no validity for high-skill tasks such as soldering.

<u>Conclusions from Previous Research</u>. In assessing the current state-of-the-art in testing, it appears that actual performance testing may be

drastically limited in scope during the early stages of SQT development. Limited resources to administer performance tests, plus the requirement for reasonable standardization of Army-wide administration, restricts the amount of performance testing. To meet the demands imposed by EPMS for career progression based on demonstrated ability to perform individual job requirements, a need exists for an alternative evaluation system that would require fewer resources yet remain faithful to the concept of performance-based evaluation.

Simulated performance tests, conceived of as job performance tests that have been degraded to some optimal level of test efficiency, show promise as an alternative. These tests require fewer personnel and less equipment to administer, use a relatively smaller amount of testing time, and permit comprehensive performance evaluation (not just the job sampling of critical tasks or key elements) as the basis for promotions, rewards, or failures.

Research Objective

To further develop and empirically verify simulated performance testing as an alternative to hands-on (HO) performance testing, research was devised to (1) develop the methodology needed for the derivation of valid simulated performance tests, and (2) provide a set of guidelines for Army item writers and SQT developers. The objective was to develop an audiovisual simulated (AVS) performance test (35mm slides and audiotape) and then validate its utility as an alternative or symbolic substitute for actual HO performance testing.

Research Approach

Research was conducted in three consecutive phases: (I) Development of an AVS Performance Test, (II) Evaluation of an AVS Performance Test, and (III) Development and Evaluation of Short Form AVS Performance Tests.

The specific approach for each phase of the research is described below.

I. DEVELOPMENT OF AN AUDIOVISUAL SIMULATED PERFORMANCE TEST

Approach

A two-step approach was taken to develop a simulated performance test. The first step was to identify the end-of-cycle (EOC) performance requirements for an armor crewman (11E) trainee completing One Station

Unit Training (OSUT).[1] This was accomplished by examining the program of instruction (POI) for 11E OSUT training together with HO performance in the EOC test currently being used by test evaluation personnel.

Based on documented training objectives and EOC test conditions and standards, each task in the EOC test was analyzed to determine the behavioral steps and elements required for successful performance. Simulated performance test equivalents for each EOC performance requirement were then developed by (a) identifying the critical behaviors in each requirement, (b) developing pictorial multiple-choice test items for the behaviors, and (c) putting these test items on 35mm slides to form a "test battery" that would parallel the EOC test for 11E OSUT trainees. Test questions were tape-recorded.

The approach reflected the prior research findings on simulated performance testing and emphasized representation of the actual situations that confront a performer during the task. Four basic principles were followed. First, the simulation test was designed to assess the mediating knowledge directly related to the specific steps and elements of the task performance, rather than the factual knowledge determined by paper-and-pencil tests. Second, the performance analogues used to provide the stimulus material for the simulation test were designed to present the behavior from the perspective of how the trainee would perform the task, and not from the perspective of a "second person" performing the task. Third, questions used to provide the response stimulus were designed to require trainees to respond in terms of what they would do, rather than what they think the person in the picture should do to perform the task. Fourth, the questions were designed to closely parallel the temporal flow of events in task performance, maintaining a subjective sense of continuity in the simulated test.

Procedure

Development of AVS Test. The majority of tasks in the EOC test were determined to be low-skill, fixed-procedure tasks. The EOC tasks identified for the 11E OSUT trainee were analyzed in terms of the sequence of subtasks and behavioral steps required to perform a task. The requirements of each step were then analyzed in terms of the specific action (A) being performed on a specific part (P), in a specific location (L), with a specific tool (T), and a specific result (R). This categorization represents a simple conceptualization of the elements of knowledge about task performance that are acquired and stored in memory as a direct result of HO practice with machine-dependent, fixed-procedure tasks. Each of these elements of subtask performance (P, T, L, A, R) were then photographed in black and white with two similar elements for use as individual test item distractors. Together, these three alternative multiple-choice test alternatives were pasted up on blue background

---

[1] 11E OSUT training combines Basic Combat Training (BCT) and Advanced Individual Training (AIT) into one 13-week program.

material, photographed using 35mm color film, and packaged in 2" x 4" plastic slides. An audio script was prepared to complete the simulated performance test.

After all slide test materials were developed for the EOC tasks, one EOC station was selected for evaluation of the simulated performance test methodology. The EOC tasks selected involved removal, disassembly, assembly, and installation of the 105mm (M68) Main Gun Breechblock mechanism. These tasks were selected because of the total amount of time, personnel, and equipment required during the EOC to test individual trainees. Currently, about 15 minutes are needed to HO test one man in one tank by one test evaluator. To complete the testing of 200 men in the time allotted for EOC, five tanks and five evaluators are required for 12 hours, allowing for retests and occasional slack time between trainees. Since EOC testing for an OSUT company is conducted nearly every week, approximately one cadre man-year is expended per year to test these tasks. Even given this expenditure, each man is tested only on two of the four tasks, either removal and disassembly, or assembly and installation. The additional resources required to test all four tasks were considered to be prohibitive.

Content Validation. Having selected the task, several subject matter experts (SMEs) were obtained for content-validation of the test materials. The SMEs were OSUT cadre assigned to test and evaluation duties. Each SME checked (a) the performance descriptions to be certain that they were properly derived from the analysis of what the trainee must know and be able to do to perform the task, (b) the part-location-tool-action-result elements to be certain that they were correctly identified for each step in the procedure, (c) the test questions for face and content validity, and (d) the verbal content of individual test questions to insure they would not be misinterpreted by the trainees. Any differences of opinion noted during the content validation were resolved by reference to the appropriate technical manual for the tasks (TM 9-2350-215-10). Changes resulting from this effort were made as required.

Critical Errors. Along with the content validation of the simulation test materials, the SMEs were asked to identify the behaviors that they thought were most critical to successful performance of the task. A task behavior was considered critical if injury to personnel or damage to equipment resulted. Other critical behaviors included errors leading to potential malfunctioning of equipment, as well as behaviors considered most difficult to perform as evident by high error rates.

Pilot Testing. With a draft version of the simulated performance test materials for the breechblock task completed, a pilot testing of the simulation test was conducted. Five OSUT trainees who successfully completed the EOC test requirements for the breechblock were obtained from their company for a 2-hour period. During this time they were individually tested on all four tasks. Problems observed or reported by the trainees during these testing sessions were subsequently reviewed with the SMEs. Any additional changes or revisions to the test materials were then made to match the simulation test items with the actual performance requirements.

A second pilot test of the materials was subsequently conducted using the revised test version. Seven trainees who completed the 11E OSUT EOC performance test on assembly and installation of the breechblock mechanisms were retested 4 days later using the simulated performance test. A similar effort was conducted with seven trainees previously tested during their EOC on breechblock removal and disassembly. Based on the results of these tests, the simulated performance test items were revised and the test was finalized. The test questions for each of the four tasks were then recorded on 60-minute audio-tape cassettes and synchronized with the corresponding test slides by means of a TELEX Cassette Slide Sync Recorder/Player. A set of trainee test directions was similarly recorded to include a practice test on the coaxial machine gun (M73/219). The purpose of the practice test was to familiarize the trainees with the testing procedures and the type of slide-tape test being administered. The response instrument selected for the test was a Monroe 326 Scientist calculator, modified to permit a trainee to enter an A, B, C, or D response by (a) pressing the numbers 1, 2, 3, and 4, respectively; and (b) pressing the start/stop button to record this answer on tape. Labels were fixed to the 1, 2, 3, and 4 calculator keys; unused keys were blocked by a cover constructed for that purpose.

Materials Developed

Test directions for the AVS performance test for removal, disassembly, assembly, and installation of the 105mm Main Gun (M68) breechblock mechanism is presented in Appendix A. A paper-and-pencil copy of the test is also shown in Appendix A. This test consists of 205 slides and takes approximately 1 hour to administer, with about 10 minutes allowed for giving the test directions, the practice test, and answering trainee questions. A breakdown of the number of test items per task and the number of test items identified as critical for successful task performance is shown in Table 1.

Table 1

Number of Critical and Continuity Test Items per Task for 105mm Main Gun (M68) Breechblock Test

Breechblock tasks	Test items		
	Critical	Continuity	Total
Removal	7	65	72
Disassembly	3	28	31
Assembly	5	25	30
Installation	5	67	72
Total	20	185	205

II: EVALUATION OF THE AVS PERFORMANCE TEST

A. DEVELOPMENT OF HO PERFORMANCE TEST CRITERION

Approach

In an earlier research effort by Cockrell (1978) in which television was used as the stimulus input to simulated performance testing, the criterion tests administered by test and evaluation personnel during the EOC period failed to provide the needed comparison measures against which to validate the simulated performance test. The "NO-GO" rates were simply too low to permit any relationship to be obtained. Several reasons were offered as possible explanations. Low "NO-GO" rates are consistently reported for most EOC tests. For example, a recent sample of 150 11E OSUT trainees failed only 3.9% of 52 EOC performance measures (ARTS, 1978).

Low failure rates may result from highly effective training, undoubtedly the case for certain tasks. However, direct observation of the EOC testing suggests that the reported performances overestimate the competence of the 11E trainee population for certain other tasks. The military test personnel responsible for EOC testing often appear to lack the training, testing instruments, and/or objectivity needed to collect reliable hands-on performance measures. It was evident that the standards for the breechblock tasks were generally ignored or liberally interpreted by the evaluators. It was also observed that many of the test personnel conducting the evaluation were the same personnel directly responsible for the specific training that was being evaluated. Although these test conditions might be acceptable during task training, they are clearly inappropriate for evaluation purposes. To improve the reliability and validity of the HO criterion data collected during this research effort it was decided to (1) develop a HO checklist for performance measurement and (2) use experienced independent evaluators in collecting the data.

Procedure

The initial attempt to develop a HO performance checklist was to list each step required to perform each task and then have the examiner merely place a checkmark in the column corresponding to whether the step was passed (GO) or failed (NO-GO). After several tryouts, this approach was found to be too imprecise for the type of simulation test developed. Information about specific errors made in task-step performance was not available from the checklist, thus making an item-by-item comparison with the AVS test impossible.

To correct the HO data collection instrument, a revised checklist was developed specifying the particular task behaviors (elements) required to perform each task step. Specifically, this included the P, T, L, A, and R elements involved in accomplishing the task steps. This checklist was tried out by an ARI staff member together with one of the military SMEs who participated in the initial content validation of the AVS test.

During several data collections using this checklist, evaluators had difficulty locating and recording appropriate task elements. Consequently, individual task-step behaviors corresponding to each AVS test item were circled on the checklist to highlight their identification during observation of task-step performance. In addition, space was left before each task step for recording the sequence in which the task steps were accomplished, and space was also provided to the right of each task step to write additional comments. After making these changes, the evaluators still experienced some difficulties in following rapid sequences of action and in observing actions that were partially obscured from view. Following additional data collection sessions using the performance checklist, it was concluded that despite the difficulties, given the proper training and incentives to collect reliable data, the data collection instrument could be used by military test personnel.

Materials Developed

A performance checklist was developed for each of the main gun breechblock tasks to obtain HO criterion data. This checklist contained a statement of individual task steps, with each step defined in terms of the actual behaviors involved specifically in task-step performance. Each task-step behavior to be evaluated in performing the task was identified by circling the letters P, T, L, A, or R opposite each requirement. Although total hands-on performance was rated, only those task-step behaviors which had a slide test counterpart were circled for performance evaluation. A copy of this performance criterion checklist is shown in Appendix B.

B. ESTABLISHMENT OF HO CRITERION RELIABILITY

Approach

Several alternative methods for deriving scores from the checklist record were considered. During the checklist tryouts, evaluators disagreed in identifying exactly which elements were involved in a performance error. The evaluators could agree that some error had occurred on a step, but not necessarily on what aspect of performance was in error. Agreement appeared to be greater when critical errors were observed. Therefore, scoring methods based on steps or critical items, rather than elements, seemed to have potential for providing more reliable (and valid) indices of performance. An interrater reliability study was designed and conducted to determine the reliability of data collected by two examiners. The military SME who had participated in the performance checklist tryouts was obtained from the 1st Training Brigade (S-3) to assist an ARI staff member in the reliability study. Together, these personnel collected all HO performance test data.

A company from the 1st Training Brigade was designated as the test company, from which a sample of trainees were selected. The company designated had recently taken the EOC test on the breechblock and was available for additional performance testing. Of the 168 trainees in the company, 137 of them had passed the EOC test the first time tested, 27 passed the second time tested, and 4 passed the third time tested.

For this study, 12 first-time GOs, 12 second-time GOs, and all third-time GOs were selected for the testing. The sample of trainees was selected by the company's first sergeant according to the order on the EOC test roster until the number of personnel required in each group was obtained. From the sample, retesting was completed with 10 first-time GOs, 8 second-time GOs, and 2 third-time GOs (N = 20). To maintain the test as it would normally be conducted during the EOC, half of each group was tested on removal and disassembly (RD) of the breechblock mechanism, and the remaining half was tested on breechblock assembly and installation (AI).

Procedure

After being informed of the research objective, each trainee completed a one-page training questionnaire (see Appendix C) concerning the amount and type of training received on the breechblock. After completing the questionnaire, trainees were randomly assigned to be tested on RD or AI and were given a HO performance test by the two test examiners positioned within a single test vehicle. The test vehicle used for the study was an M60A1 tank with an add-on stabilization system (AOS). Each test took approximately 30 minutes to complete. Testing was conducted for 2 days at the 1st Training Brigade motor pool.

Results

The reliability of the HO data collected independently by two different evaluators, each with identical HO performance checklists, was analyzed by three different scoring methods: (1) total number of errors committed; (2) total number of incorrect steps, i.e., steps with one or more errors; and (3) the total number of critical errors committed. The criterion level adopted for acceptable interrater reliability was $r \geq .80$.

The results of the data analysis are shown in Table 2. When using total number of errors committed as the scoring method, an interrater reliability of $r = .86$ was established for RD and a reliability of $r = .83$ for AI. When the four tasks were analyzed individually, only breechblock installation had an acceptable reliability ($r = .85$), although all coefficients are statistically significant.

Table 2

Interrater Reliability Coefficients[a] for Three Methods of Scoring Hands-On Test Performance On the 105mm Main Gun (M68) Breechblock Tasks

Task	Scoring method: Errors	Incorrect steps	Critical errors
Removal	.69	-.02	.79
Disassembly	.74	.80	1.00
Combined	.86	.39	.93
Assembly	.68	.64	.84
Installation	.85	.74	.89
Combined	.83	.78	.88

[a]For df = 8, r = .63 is significant with p = .05.

Analysis of these data using the total number of incorrect steps failed to establish an acceptable reliability between evaluators on any of the four tasks, either individually or combined. These results indicate that the evaluators were no more reliable in identifying errors on particular steps than they were in identifying the particular elements in error.

The third method used to score HO performance was to identify the number of critical errors made in task performance. For this measure, the interrater reliabilities were consistently higher than those found for other measures. The reliabilities were acceptable for both RD (r = .93) and AI (r = .88). Only the separate task of breechblock removal (r = .79) was found to be slightly below the criterion level adopted for acceptable reliability. Based on these results, the number of critical errors was adopted as the measure of HO performance to be used in subsequent research.

The difficulties experienced in identifying errors for particular elements or procedural steps have important implications for HO performance testing. Even experienced evaluators have difficulty in following the details of actions that occur in rapid succession and that may be partially obscured from view. In addition, it is difficult to accurately observe and record information on a very large number of details of a performance process. The present results suggest that more reliable observations may be obtained when attention is focused on a smaller number of elements of performance that have been determined to be critical to task performance according to established criteria.

Summary

In the four tasks scored by independent evaluators, consistently higher reliabilities were obtained when performance was measured based on total number of critical errors. Alternative methods of scoring task performance were found to have less or inconsistent reliability. Difficulties experienced in identifying errors on particular performance elements or steps indicate that improved HO test evaluation may result from focusing observation on critical errors. The number of critical errors was used as the primary criterion measure of HO performance throughout the research as reported later in this paper.

C. COMPARISON OF AVS VERSUS HO PERFORMANCE TESTING

Approach

A research design involving two groups was used to compare the AVS test with HO test performance. Table 3 shows the sequence of tests given to each group. In Group A, 11E OSUT trainees were administered the AVS test followed by the HO test. Within this group, half of the trainees took the test on the breechblock removal and disassembly (RD) tasks, and the remaining half took the test on assembly and installation (AI) tasks. In Group B, trainees were administered the HO test first, followed by the AVS test and a second HO test. Again, half the trainees took the RD test, and the remaining half took the AI test. This arrangement permitted an examination of possible transfer between HO and AVS tests, whereas AVS data from both groups can be combined in predicting subsequent HO performance.

Participants were 112 11E OSUT trainees. Sixteen trainees awaiting their EOC examination were obtained from each of seven consecutive OSUT companies over a 10-week period. For each company, trainees were randomly selected approximately 3 days prior to testing and randomly assigned to Group A or B.

Procedure

The testing procedure used throughout the study was to gather all the trainees together immediately prior to testing and inform them of the research effort. Privacy Act requirements were explained, followed by the administration of the one-page training questionnaire used during the interrater reliability study (see Appendix C). After all questionnaires were completed, each trainee was given a 3" x 5" card containing his testing schedule and directed to his test station. The two trainees to be immediately HO tested were directed to Tank 1 or Tank 2, and the

Table 3

Experimental Design for Comparison of Simulated Versus Hands-On Test Performance

Group	Tasks[a]	n	Test[b] 1	2	3
A	RD	30	AVS	HO	--
	AI	28	AVS	HO	--
B	RD	26	HO	AVS	HO
	AI	28	HO	AVS	HO

[a]RD = Removal and disassembly of the breech.
AI = Assembly and installation of the breech.

[b]AVS = Audiovisual slide test.
HO = Hands-on performance test.

two trainees to be AVS tested first were directed to the testing room. All other trainees were sent to a holding area and placed under the supervision of an NCO.

<u>HO Test</u>. For the hands-on performance evaluations, the ARI and 1st Training Brigade test examiner were each assisted by a tank commander (TC) from the company cadre and known by the trainees. When a trainee entered the tank he was informed of the test procedures by the TC and encouraged to perform to the best of his ability and within the time standards specified for the tests. Time required to perform the separate tasks, as well as the critical and other performance errors, were recorded by the test examiners. After the trainee completed the first HO test, the TC told him to report back to the NCO in charge at the holding area for additional testing (Group B) or to report back to his drill sergeant (Group A). Trainees passing the HO performance test during the research effort were excused from the breechblock test during the regular EOC test period the following day. However, trainees failing the HO test were required to take the EOC breechblock test.

<u>AVS Test</u>. For the AVS test, two trainees were seated in front of a screen with a Monroe 326 Scientist calculator on a table in front of them. As noted earlier, these calculators recorded trainee responses on a continuous cassette tape. Answers recorded by the trainee could be recalled after testing was completed and scored. Test directions previously recorded on audio-tape were then played to the trainees along with a practice test. During this practice, the test administrator

determined the ability of the trainees to follow the procedures for recording test answers in the response device. Problems in using the response device were corrected before the test began, and trainee questions concerning the test were answered.

After the test began, the only time the AVS test was stopped was when an error was made in using the response device. The ARI test administrator then recorded the intended answer on paper and, if necessary, advanced the machine to the proper test question. When the AVS test was completed, the trainees were sent to the NCO at the holding area.

Scoring and Data Analysis

AVS test responses and HO performance checklists were scored to determine the number of critical errors committed. The number of critical errors tended to have a J-shaped distribution for both types of tests, with a predominance of zero scores. Given these distributions, and also to be consistent with a criterion-referenced testing approach, categories of performance were defined based on critical errors.

Both HO and AVS performance were dichotomized, with zero critical errors required for a pass rating. AVS performance was also trichotomized, with zero critical errors required for a pass rating, one critical error was a borderline rating, and two or more errors was a fail rating.

The relationship between performance on the AVS test and the following HO test was examined for both two-by-two and three-by-two contingency tables. For two-by-two tables, phi coefficients were computed, and statistical significance was determined by the chi-square test of independence. The correction for continuity was not used in these tests (Camilli & Hopkins, 1978). For the three-by-two tables, Kendall's tau (τ) was computed and tested by the normal approximation (z) with corrections for ties (Kendall, 1975).

Transfer effects were investigated by performing chi-square tests of homogeneity (Camilli & Hopkins, 1978) between groups. To determine transfer from HO to AVS test, the percentage passing the AVS test was compared between Group A (AVS test given first) and Group B (AVS after HO test). Transfer from AVS to HO was evaluated by comparing the percentage passing the first HO test in Group B (HO test given first) to the percentage passing the HO test in Group A (HO after AVS). Finally, transfer from HO to HO tests was examined by comparing the pass rate in the last HO test in Group A (HO after AVS) to that in Group B (HO after HO and AVS).

The relationship between practice and test performance was examined by comparing the frequency of various types of practice (as reported on the training questionnaire, Appendix C) for the group that passed against the group that failed for each test. The Mann-Whitney U-test (Siegel, 1956) was performed to determine the statistical significance of the differences in the distribution of frequencies, using the large sample normal approximation (z) test statistic.

Results

Comparison of AVS and HO Tests. The relationships found between AVS and HO test performance are summarized in Table 4, based on two categories of AVS test performance, and in Table 5, based on three categories of AVS performance. Two-by-three contingency tables (pass-borderline-fail) for Groups A and B and the total sample are shown in Table D-1. The results are described below for each task.

Table 4

Correlation Coefficients[a] and Tests of Independence[b] Between HO Test Performance and Prior AVS (Long Form) Test Performance on 105mm Main Gun (M68) Breechblock Tasks

Tasks	Percentage passing HO test		ϕ	χ^2
	Passed AVS	Failed AVS		
Removal	83.3	52.6	.296	4.91*
Disassembly	98.0	100.0	-.051	0.14
Assembly	88.2	38.5	.459	11.79**
Installation[c]	50.0	46.7	.033	0.06
Installation[d]	92.9	67.9	.315	5.54**

*Significant with $p < .05$ (one-tailed).
**Significant with $p < .01$ (one-tailed).

[a]Phi coefficients (ϕ).

[b]Chi-square (χ^2).

[c]Includes skill element in scoring

[d]Excludes skill element from scoring.

Table 5

Correlation Coefficients[a] and Tests of Significance[b]
Between HO Test Performance and Prior AVS (Long Form)
Test Performance on 105mm Main Gun (M68) Breechblock Tasks

Tasks	Percentage passing HO test				
	Passed AVS	Borderline	Failed AVS	τ	z
Removal	83.3	65.0	38.9	.479	2.72*
Disassembly[c]	98.0	100.0	----	-.051	0.32
Assembly	88.2	57.1	16.7	.536	3.83*
Installation[d]	50.0	50.0	41.7	.050	0.38
Installation[e]	92.9	75.0	58.3	.431	2.53*

*Significant with $p < .01$ (one-tailed).

[a]Kendall's tau (τ) with correction for tied ranks.

[b]Normal approximation (z) with correction for tied ranks.

[c]No trainees made more than one error on the AVS test, so $\tau = \phi$.

[d]Includes skill element in scoring.

[e]Excludes skill element from scoring.

Removal. A significant relationship with HO performance was observed with either two or three categories of AVS test performance. As Table 4 indicates, there was more than an 80% chance of passing the HO test when no critical errors were committed on the AVS test. If one or more critical errors was made on the AVS test, chances of passing the HO test dropped to about 50-50. Table 5 shows that making more than one error was more serious, since the percentage passing for the AVS fail group is substantially lower than for the borderline group.

Disassembly. No significant relationship between AVS test and HO test could be demonstrated for this task, since only 1 trainee out of 56 failed the HO test, and that trainee passed the AVS test. Seven trainees made one critical error on the AVS test and were classed as borderline, but all passed the HC test. This task had the lowest number of AVS errors observed among the four tasks as well as the least number of HO failures.

Assembly. A strong relationship between HO and AVS test performance was found for this task. The correlation coefficients were significant both for two and three categories of AVS test performance. Nearly 90% of the AVS pass group also passed the HO test. The percentage was much lower for the remaining trainees. With more than one critical AVS error, less than 20% of the trainees were able to pass the HO test.

Installation. Initial analysis of the data (Table 4) indicated that the relationship between the simulated and performance tests was not significant. Examination of the data for individual items indicated that a single critical task behavior was responsible for the lack of test correlation. In the AVS test, trainees were to correctly identify the number of "clicks" they should raise the breechblock after depressing the second extractor plunger. Most of the trainees tested (85%) correctly identified the requirement to raise the breechblock "two clicks." When they were tested hands-on, fewer than half (44%) could apply this knowledge.

Observations indicated that when the breechblock came under less tension, and could therefore be raised quite easily, the trainees sometimes failed to control the chain-hoist and raised the breechblock beyond the position needed to insert the pivot pin. As a result, they had to lower the breechblock and repeat several earlier task behaviors. Obviously, the two test items were not equivalent. Knowing what to do failed to guarantee being able to carry out the required behavior. Apparently, this task step involved an element of skill not represented in the AVS item. A hands-on test of this particular skill component is required to supplement the AVS test covering the remainder of the installation task. Together, the AVS test and the partial HO test would provide a complete synthetic test for the installation task. Data on AVS test performance including and excluding the skill element is shown in Table D-2.

Reanalysis of the data without the skill element is presented in Tables 4 and 5. In both cases, there was a significant relationship between HO and AVS tests. Over 90% of those who passed the AVS test also passed the hands-on test; about one-third of those who failed the AVS test also failed the HO test. The difference between the borderline group and the AVS fail group (Table 5) was not as great for this task as it was in the removal and assembly tasks, but it was still in the right direction.

Summary. In three out of four tasks, a significant relationship between AVS and HO test performance was demonstrated. For each of these tasks, a high percentage of trainees passed the HO test when they made no critical errors on the AVS test. The trainee's chance of passing the HO test was lower if he made one critical error, and even lower if he made more than one error. Over the three tasks, the percentages passing the HO test were 97.5% in the AVS pass group, 64.9% in the borderline group, and 35.4% in the AVS fail group. Although the relationship between HO and AVS test performance is far from perfect, it is nonetheless quite useful from a practical standpoint.

The occurrence of a skill element in the installation task which could not be tested by the AVS test is an important finding. Comparison of AVS and HO performance on critical items provides a methodology for identifying elements of performance that must be HO tested. When a large proportion of trainees pass an AVS test item, but a much smaller proportion pass the corresponding HO item, a skill element is indicated. Detailed observations and behavior analysis should then be conducted to substantiate the presence of a skill element. For most of the critical nonskill items in these tasks, a lesser proportion of trainees passed the AVS item than passed the corresponding item in the subsequent HO test. This may reflect the difference in stimulus and response fidelity existing between the HO test situation and its representation in the AVS items.

The breechblock assembly task was found to be very easy, so that no relationship between AVS and HO tests could be demonstrated. However, this task was by far the easiest of the AVS tests (12.5% failed) as well as the HO tests (2% failed). At a lower level of training, a relationship similar to that of the other tasks might be found for the assembly task as well.

Transfer, Practice, and Prediction of HO Performance from Testing. The analyses presented in Tables 4 and 5 combined Groups A and B using data from the AVS test and the HO test which followed. Assessment of transfer from the AVS to HO test performance, and from HO to AVS test performance, is of interest in two respects. First, transfer from AVS to HO test might be responsible for the fact that more trainees passed the HO test than the AVS test in every task. Second, transfer from the AVS test, or from the first HO test in Group B, might have altered the relationship between AVS and HO tests so that the data were not an accurate reflection of the "true" relationship that might be obtained if the effects of transfer could be removed.

In the event transfer is not observed, the data of Group A and B permit the investigation of a further comparison, i.e., whether an AVS test is less valid than a HO test in predicting later HO performance. This comparison bears directly on the possible utility of AVS tests as a substitute for HO testing.

One explanation for differences in task difficulty may be that trainees practiced some breechblock tasks more than other tasks. Data from the training questionnaire were analyzed as a check on this possibility.

Transfer from Testing. Results pertinent to the transfer questions are summarized in Table 6. When performance on the first HO test is compared between Groups A and B, the prior AVS test in Group A appears to have raised the proportion passing by 10% to 15% in the removal, disassembly, and installation tasks. However, none of the chi-square tests of homogeneity for these proportions was significant, so there is no statistical evidence for positive transfer from AVS to HO test. Based on these results, the practice effect provided by the AVS test is small, if it exists at all. Therefore, it does not seem that transfer effects can explain the higher performance observed in the HO test as compared to the AVS test. The AVS test appears to be a somewhat more difficult form of testing.

Table 6

Practice Effects Produced by Prior Testing for 105mm Main Gun (M68) Breechblock Tasks

Tasks	Percentage passing first HO test: Prior AVS (Group A)	Percentage passing first HO test: No prior AVS (Group B)	χ^2
Removal	63.3	50.0	1.01
Disassembly	100.0	88.5	3.66
Assembly	35.7	42.9	0.30
Installation[a]	39.3	42.9	0.07
Installation[b]	75.0	60.7	1.31

Tasks	Percentage passing AVS test: Prior HO (Group B)	Percentage passing AVS test: No prior HO (Group A)	χ^2
Removal	34.6	30.0	0.14
Disassembly	88.5	86.7	0.04
Assembly	46.4	14.3	6.84*
Installation[a]	39.3	53.6	1.15
Installation[b]	46.4	53.6	0.29

Tasks	Percentage passing final HO test: Prior HO, AVS (Group B)	Percentage passing final HO test: Prior AVS (Group A)	χ^2
Removal	61.5	63.3	0.02
Disassembly	96.2	100.0	1.18
Assembly	71.4	35.7	7.18*
Installation[a]	57.1	39.3	1.79
Installation[b]	85.7	75.0	1.02

*Significant with $p < .01$.

[a] Includes skill element in scoring.

[b] Excludes skill element from scoring.

The first HO test did produce a substantial practice effect for the assembly task. This was found comparing the AVS test, as well as the subsequent HO test, between Groups A and B. The percentage passing was over 30% higher for Group B and was statistically significant in both cases. Since the practice effect that occurred for both assembly tests did not occur for the other tasks, and there was no substantial transfer from the AVS test, pooling of data on the final HO test from Group A and B is justified. The relationships demonstrated between AVS and HO test performance should be reasonably representative of the relationship that exists without repeated testing of the same individual. However, the relationship may have been somewhat strengthened for the assembly task, since a wider range of abilities may have been assessed on that task because of the transfer effect.

Prediction of Subsequent HO Performance. Considering the high AVS-HO relationship, lack of transfer from AVS to HO test performance is a particularly important finding, since AVS test methods may be used to assess the current level of HO test ability without having a substantial effect on HO performance. The present results indicate that, given the number of critical errors on an AVS test, HO test critical errors can be expected to be less than or equal to that number in most cases. Thus it may be possible to pass those who have no critical errors on an AVS test without giving a more costly HO test, and suffer no more incorrect decisions than would be made using a HO test alone.

Analyses relevant to this possibility are presented in Table 7, which shows HO test performance as a function of prior AVS test performance (Group A) in comparison with HO test performance as a function of prior HO performance (Group B). This comparison is only valid for the removal and installation tasks where there was no transfer from HO testing to subsequent HO performance. Performance of Group B is biased upwards on the assembly task data, which showed a significant practice effect. The disassembly task is also not relevant, since only one trainee failed the task. The basic data are shown in Table D-3.

For both the removal and installation tasks, the prediction of subsequent HO test performance tended to be higher from a prior AVS test than from a HO test. The correlations are significant with AVS test performance for both tasks and not significant with the prior HO test for both tasks. Surprisingly, the prior HO tests had no relationship to subsequent HO performance on the removal task.

Considering all tasks, a pass given on the basis of an HO test was never much better than a pass given on a AVS test as an indication of the trainees' ability to perform the task, as assessed in a HO retest of that ability. In the removal task, the AVS test was clearly a better indication of later ability to do the task than was the HO test! These results indicate that AVS tests, under some circumstances, may be a more reliable method of testing than HO testing itself. This finding requires additional confirmation in further research. In the present study, the relationship between HO tests may have been disturbed by the

Table 7

Comparison of Relationships Between HO Test Performance
and Prior AVS or HO Test Performance

Tasks	With prior HO test, percentage passing HO test: HO pass	HO fail	ϕ	χ^2
Removal	61.5	61.5	0.000	0.00
Disassembly	95.7	100.0	-0.072	0.14
Assembly	80.0	62.5	0.228	1.46
Installation[a]	94.1	72.7	0.299	2.50

Tasks	With prior AVS test, percentage passing HO test: AVS pass	AVS fail	ϕ	χ^2
Removal	100.0	47.6	0.498	7.44*
Disassembly	100.0	100.0	-----[c]	----[b]
Assembly	75.0	29.2	0.209	1.22
Installation[a]	93.3	53.8	0.454	5.79*

*Significant with $p < .01$ (one-tailed).

[a]Excluding skill element from scoring.

[b]Not computed, since no trainees failed the HO test.

intervening AVS testing, even though no net positive or negative transfer effect from AVS testing was observed.

Training Questionnaire. Data on the frequencies of various types of training experiences are summarized in Table 8. In training, removal and disassembly as well as assembly and installation are always done together, so that the frequencies reported were identical for each of these pairs of tasks. The data indicate a similar pattern of training in both cases, with the instructor demonstrating once, each trainee practicing twice himself, and observing other trainees about three times.

Interestingly, the instructor's demonstration is not reported in several instances. The differences between means and modes suggest that in some cases a little less training is given on the assembly and installation tasks. However, the differences are not sufficiently large to

Table 8

Frequency of Types of Practice Reported on the Training Questionnaire for 105mm Main Gun (M68) Breechblock Tasks

Type of practice	Removal and disassembly (percentage) Mean	Mode	None
Observe instructor	1.35	1	16.4
Observe trainee	3.02	3	3.6
Hands-on practice	2.05	2	3.6
Total	6.49	5	3.6

Type of practice	Assembly and installation (percentage) Mean	Mode	None
Observe instructor	1.25	1	12.5
Observe trainee	2.95	2	0.0
Hands-on practice	1.70	1	5.4
Total	5.89	4	0.0

account for the difference in difficulty observed between the disassembly and assembly tasks.

Differences in reported training were examined between the groups of trainees that passed and failed each task. Only a few significant differences were found, and the direction of the differences was not consistent. For these data, there was no strong relationship indicated between amount of practice and HO and AVS test performance. The results of these comparisons are presented in Appendix E.

Summary

No evidence of transfer from the AVS testing to HO performance was obtained. On this basis, AVS tests may be used to assess performance capability without markedly modifying those capabilities. This finding can be expected to generalize to other tasks, since the AVS tests provide very limited sources of intrinsic performance feedback. In contrast, transfer from HO to AVS test performance and HO performance was found for one task (assembly). Transfer from HO testing can be expected to result from intrinsic feedback provided by task performance.

Prediction of HO test performance was examined for tasks that did not show transfer. Prediction from AVS test performance was as good as prediction from HO performance for both removal and installation tasks. For the removal task, HO test results did not predict subsequent HO performance at all.

Differences in frequencies of reported practice were not sufficient to account for differences in difficulty among the tasks. No consistent relationship was found between reported practice and performance on either AVS or HO tests.

III. DEVELOPMENT AND EVALUATION OF SHORT-FORM AVS PERFORMANCE TESTS

With the results of the comparison study supportive of the simulated performance test developed, the next phase of the research effort was to suggest a methodology for developing an audiovisual simulated performance test based on the lessons learned from developing the breechblock AVS test. This methodology is presented in Appendix E.

Two major departures from the procedure used in developing the breechblock test (long form) were considered important. First, difficulties experienced in 35mm photography and production of slides suggested that use of instant print photography in development of a preliminary paper-and-pencil test could speed up the AVS test development process. Second, the AVS tests for the breechblock appeared to contain an excessive number of items, particularly since many of the items did not contribute to test validity. It was desirable to reduce the test length, if that could be done without compromising test validity.

To determine the adequacy of the methodology developed for AVS performance rating, two brief studies were conducted. In the first study, the AVS test developed initially for the removal, disassembly, assembly, and installation of the 105mm Main Gun (M68) breechblock mechanism was modified (abbreviated) and a final comparison made between it and the HO performance test. In the second study, a short-form AVS performance test was developed for a different EOC task and compared with its HO performance test equivalent. The specific test development approach and procedures followed in conducting these studies, as well as the study results, are described below.

STUDY I: MAIN GUN BREECHBLOCK MECHANISM

Test Development

Approach. Based on the original long-form AVS test, it was only necessary to carry out tasks 5, 8, and 9 of the methodology outlined in Appendix F to develop a shortened form of the AVS test. Individual slide test items which were noncritical were analyzed; those found to be passed by nearly all trainees tested during the initial test development were excluded from the revised AVS test, and those test items that were failed or found to be more difficult were included. The only exception to this method was when test items passed by the majority of trainees were needed to maintain total task test continuity.

Materials. Following this approach, a short-form AVS performance test using 35mm color slides was developed for the removal, disassembly, assembly, and installation of the 105mm Main Gun (M68) breechblock mechanism. The AVS test consisted of 45 items (slides) and took approximately 30 minutes to administer, compared to the 205 items and 1 hour for the original test. This included 5 minutes for test directions and practice testing, 5 minutes for answering trainee questions, and 20 minutes for test administration. A breakdown of the number of test items per task along with the number of test items identified as critical for successful task performance is presented in Table 9. Appendix G contains the AVS test directions and the paper-and-pencil copy of the AVS test and answer sheet. Performance elements corresponding to the short-form AVS test items are indicated by number on the HO checklist copy also shown in Appendix G.

Table 9

Number of Critical and Continuity Test Items per Task for 105mm Main Gun (M68) Breechblock Test

Breechblock tasks	Test items: Critical	Test items: Continuity	Total
Removal	7	9	16
Disassembly	3	0	3
Assembly	5	3	8
Installation	5	13	18
Total	20	25	45

Test Evaluation

Method. The short-form AVS breechblock test was evaluated to determine if the test remained valid after elimination of 78% of the items. Two platoons of 11E OSUT trainees were administered the test 1 day prior to their EOC test. Based on the results of the AVS test, 10 trainees having the largest numbers of critical errors (mean = 7.4) for RD and AI were selected with 10 other trainees having the smallest numbers of critical errors (mean = 1.6) for RD and AI. Five trainees from both the high and low error groups were then assigned to one of the two HO performance test groups.

Individual trainees selected for the study were notified of their selection at the start of the EOC test and told by the NCOIC to report to the breechblock station for testing. On arrival at the test station they were instructed by the ARI test examiner to line up behind one of two tanks in alternating task order; i.e., removal-disassembly, assembly-installation. The test evaluators were the same individuals used during the long-form AVS test evaluation effort. Procedures used throughout the HO data collection were the same as those in the earlier breechblock testing.

Results. Relationships between AVS and HO test performance are summarized in Tables 10 and 11. Two-by-three contingency tables (pass-borderline-fail) are presented in Table G-1. Fisher exact tests were used to determine the statistical significance of the relationships reported in Table 10. For these data, small expected frequencies prevent the use of chi-square. In scoring HO tests, it is a common practice to combine performance measures on subtasks, giving a "GO" rating on the overall task only if a "GO" is obtained in each subtask. The usual procedure in the 1st Brigade was to test only on the removal and disassembly tasks, or on assembly and installation, and to pass the trainee only if performance was rated "GO" on both tasks. Therefore, it was interesting to determine whether the relationships between HO and AVS testing was maintained for combined tasks as well as individual ones. The results of the short-form test evaluation for the main gun breechblock mechanism are presented below for both individual and combined task performance.

Table 10

Correlation Coefficients[a] and Tests of Independence[b] Between HO Test Performance and Prior AVS (Short Form) Test Performance on 105mm Main Gun (M68) Breechblock Tasks

Tasks	Percentage passing HO test		ϕ	p
	Passed AVS	Failed AVS		
Removal	100.0	14.3	.802	.033*
Disassembly	100.0	83.3	.272	.600
Combined	100.0	25.0	.612	.133
Assembly	66.7	42.9	.218	.500
Installation[c]	100.0	50.0	.667	.200
Combined[c]	66.7	42.9	.218	.500

*Significant with $p < .05$ (one-tailed).

[a]Phi coefficient (ϕ).

[b]Fisher exact probability (p).

[c]Excludes skill element from scoring.

Table 11

Correlation Coefficients[a] and Tests of Significance[b] Between HO Test Performance and Prior AVS (Short Form) Test Performance on 105mm Main Gun (M68) Breechblock

Tasks	Percentage passing HO test			τ	z
	Passed AVS	Borderline	Failed AVS		
Removal	100.0	0.0	20.0	.587	1.74*
Disassembly	100.0	100.0	50.0	.471	1.30
Combined	100.0	100.0	14.3	.766	2.24*
Assembly	66.7	100.0	33.3	.385	1.08
Installation[c,d]	100.0	50.0	----	.667	1.75*
Combined[c]	66.7	100.0	33.3	.385	1.08

*Significant with $p < .05$ (one-tailed).

[a]Kendall's tau (τ) with correction for tied ranks.

[b]Normal approximation with correction for tied ranks.

[c]Excludes skill element from scoring.

[d]No trainees made more than one error on the AVS test, so $\tau = \phi$.

Removal. The results of the data analysis indicated a significant relationship between the AVS test and the HO test based on either two or three categories of AVS test performance. All trainees who passed the AVS test and were thus predicted to pass the HO test did, in fact, pass. Only 14% (one of seven) of those who made one or more errors on the AVS test were able to pass the HO test.

By way of comparison, these results indicate that the relationship of the short-form AVS test with HO test performance appeared to be no less than that obtained previously with the long form of the AVS test.

Disassembly. There was no significant relationship between the AVS and HO tests for this task. The results obtained, by comparison with the earlier study, were quite similar in that only one trainee actually failed the HO test. Without a certain number of such task failures, a significant correlation coefficient cannot be obtained.

Removal and Disassembly (Combined). When the easy disassembly task was combined with the harder removal task, the correlation coefficients were similar to those obtained for the removal task alone. The results for the combined tasks failed to indicate a significant relationship between the AVS and HO tests when AVS test performance was dichotomized. However, the relationship remained significant when predicting from three categories of AVS test performance. As Table 11 shows, all those who made zero or one error on the AVS test passed the HO test, while only one out of seven passed the HO test with two or more AVS test errors. Despite the fact that the relationship was not significant with two categories, the results indicate that little prediction power was lost when the tasks were combined.

Assembly. No significant relationship was established between the AVS and HO tests in either analysis. In comparison with the earlier research findings, the relationships were somewhat weaker than those obtained with the long form, although they still tend to be in a positive direction.

Installation. This task was much easier than was the case previously, with only one trainee in the present sample failing the HO test. Although the coefficients of correlation were higher than those observed for the long form and the coefficient was significant for three categories of AVS test performance, no definite conclusion can be reached because of the small number of HO failures.

Assembly and Installation (Combined). The results for the combined test were identical to those for the assembly task, which was the more difficult task in this case. No significant relationship between AVS and HO test performance was found in either analysis.

Summary. The small sample of data obtained for this study preclude any firm statistical conclusions about the effects of abbreviating the long form of the AVS breechblock test. A definite relationship between HO and AVS tests was only found for the removal task. In other cases the results were in a positive direction but nonsignificant due to the small number of HO failures.

Considered together, the findings are nonetheless promising, since the short-form results were actually quite close to those obtained with the long-form AVS test. Overall, 94.4% of those who had zero errors on the AVS test also passed the HO test, compared to 66.7% of those with one error, or 30% of those with two or more errors. These percentages are quite similar to those obtained with the long-form AVS test, although extreme groups were selected for the present sample.

With respect to the effects of combining tests, the results suggest (as might be expected) that the relationship between AVS and HO tests will largely be a function of that obtained with the more difficult of the subtests entering into the combination. In developing an AVS test, any subtest found to be very easy should probably be combined with a more difficult subtest in preference to entirely eliminating it from the test. Under other circumstances, such as less effective training, the subtest would not necessarily prove to be so easy. The combined test would still permit errors on the easy subtest to be detected, whereas if the subtest were eliminated the possibility for such errors would pass undetected.

STUDY II: COAXIAL MACHINE GUN (M73/219)

Test Development

Approach. The AVS performance test development methodology (except for Task 6) in Appendix F was used to develop an AVS test for five coaxial machine gun (M73/219) tasks. Where possible, the 35mm slide materials developed for the machine gun at the beginning of the project were used. Additional slides were required to develop an AVS test for removing a stoppage. In this case, all test materials were prepared from analyzing the job task description data (Task 1), through pilot testing (Task 8), omitting Task 6. The test directions and the practice test were adapted from the AVS test developed for the main gun breechblock.

Materials. Following the suggested methodology, an AVS performance test was developed for the coaxial machine gun (M73/219). This AVS test included the tasks of clearing, disassembly, assembly, conducting a function check, and removing a stoppage. Allowing 5 minutes for test directions and practice testing, and an equal amount of time for answering trainee questions, the AVS test contained 81 test items and took approximately 35 minutes to administer. The number of items for the five machine gun tasks are presented in Table 12. A copy of the test directions, the paper-and-pencil copy of the AVS test and answer sheet, and the checklist used for HO performance evaluation are shown in Appendix H.

Table 12

Number of Critical and Continuity Test Items (Slides) per Task for the Coaxial Machine Gun (M73/219)

	Test items		
Machine gun tasks	Critical	Continuity	Total
Clearing	12	8	20
Disassembly	4	10	14
Assembly	3	13	16
Function check	8	3	11
Stoppage	12	8	20
Total	39	42	81

Test Evaluation

Method. One platoon (N = 17) of 11E OSUT trainees from the 1st Training Brigade who had completed training and were waiting for their EOC test were selected for testing. All 17 trainees were to be administered the AVS test, followed by immediate HO performance testing. Only 10 trainees, however, were made available for the HO testing. The remaining 7 trainees had to be evaluated during their EOC test being conducted on the following day.

For the immediate performance test data collection effort, four ARI personnel who had been trained to evaluate the task were used as test evaluators. During the test, each trainee's performance was independently scored by each of the four evaluators. Any differences obtained between evaluators were resolved upon test completion, and a single task performance record was prepared for each trainee. For the EOC hands-on data collection effort, two of the above evaluators were used to observe and evaluate each of the seven trainee's task performance. For these trainees, only pass or fail judgments were obtained.

In scoring AVS test performance, trainees making one error were classified as borderline on individual tasks. For combined tasks, however, trainees with either one or two errors were classified as borderline. In all cases, zero errors were required for a pass rating.

Results. Relationships between HO and AVS test performance for the machine gun tasks are summarized in Tables 13 and 14. Two-by-three contingency tables are reported in Table H-1. The results of the AVS test evaluation study are presented below for each coaxial machine gun task and combined tasks.

Clearing and Disassembly. For both tasks, chances of passing the HO test were best for those making no errors on the AVS test and were lowest for those making more than two errors. Reflecting this relationship, moderate positive correlations were found for both tasks. However, none of the correlations was found to be statistically significant.

With one or two errors allowed for a borderline rating on the combined tasks, the relationship between AVS and HO performance was somewhat strengthened. All who failed the combined HO test had more than two AVS errors. As shown in Table 14, the tau coefficient was significant for the combined clearing and disassembly task.

Assembly and Function Check. Chances of passing the HO test were best for those making no AVS test errors and least for those making more than two errors. While the tau coefficients were found to be significant both for separate and combined tasks, there was only one HO test failure in each case, so that the normal approximation is suspect for these data. Although the tasks were too easy to provide strong support for a relationship between AVS and HO tests, the data at least were not inconsistent with the overall pattern of results.

Table 13

Correlation Coefficients[a] and Tests of Significance[b] Between HO Test Performance and Prior AVS Test Performance on Coaxial Machine Gun (M73/219) Tasks

Tasks	Percentage passing HO test: Passed AVS	Percentage passing HO test: Failed AVS	ϕ	p
Clearing	100.0	64.3	.299	.324
Disassembly	90.0	57.1	.381	.162
Combined	100.0	53.3	.306	.331
Assembly	100.0	66.7	.540	.176
Function	100.0	75.0	.450	.235
Combined	100.0	75.0	.450	.235
Stoppage	100.0	70.0	.387	.176

[a]Phi coefficient (ϕ).

[b]Fisher exact probability (p).

Table 14

Correlation Coefficients[a] and Tests of Significance[b] Between HO Test Performance and Prior AVS Test Performance on Coaxial Machine Gun (M73/219) Tasks

Tasks	Percentage passing HO test: Passed AVS	Percentage passing HO test: Borderline	Percentage passing HO test: Failed AVS	τ	z
Clearing	100.0	100.0	58.3	.397	1.58
Disassembly	90.0	66.7	50.0	.383	1.54
Combined	100.0	100.0	36.4	.584	2.35*
Assembly	100.0	66.7	----	.540	2.16**
Function	100.0	-----	75.0	.451	1.66**
Combined	100.0	100.0	50.0	.501	1.92**
Stoppage	100.0	80.0	60.0	.412	1.68**

*Significant with $p < .01$ (one-tailed).
**Significant with $p < .05$ (one-tailed).

[a]Kendall's tau (τ) with correction for tied ranks.

[b]Normal approximation (z) with corrections for tied ranks.

Stoppage. For this task, HO performance decreased with AVS errors, and moderate correlations were found both for two and three categories of AVS performance. With three categories, the tau coefficient was significant.

Summary. The relationship between HO and AVS test performance was not as strong for the machine gun tasks as that found for the breechblock tasks. In part, these results reflect the higher level of performance on the machine gun tasks. For the machine gun, 83.5% of all tasks were passed, whereas only 67.5% of breechblock tasks were passed by the short-form sample, and 73.7% by the long-form sample. With a high rate of passing and a small sample of trainees, strong statistical support for the relationship could not be obtained.

Nevertheless, the data on the machine gun tasks present very much the same type of picture as that obtained with the breechblock tasks. Overall, 97.9% of those passing the AVS test also passed HO test, compared to 76.9% of those borderline on the AVS test or 60% of those failing the AVS test. These results indicate that the approach taken in developing the breechblock and machine gun AVS tests could be expected to be successfully applied to other tasks having simiiar characteristics.

DISCUSSION

Major Findings

Relationship Between AVS and HO Tests. Using slide-tape AVS tests to predict HO performance, a consistent type of relationship was obtained throughout the present research. Trainees making no errors on an AVS test had a high probability of passing the corresponding HO test. Although failure on a HO test could not be predicted with equal certainty, the probability of passing a HO test was much reduced for those making AVS test errors.

The present results indicate that a well-validated AVS test may be used as a performanced-based criterion to screen examinees. Using an AVS test criterion, the decision to pass an examinee has no more risk of passing an unqualified examinee than would result from a parallel HO test. Under some circumstances, the AVS test may be more predictive of subsequent HO performance than a HO test itself, as was found for one breechblock test.

In most cases, examinees making only one error (borderline) had a higher probability of passing a HO test than those making more than one error. When a three-category decision scheme is used with an AVS screening test, those classed as borderline might be given relatively brief remedial or refresher training, perhaps only concerning the critical element of performance where the error was committed. Those examinees making several errors should probably be given more extensive HO retraining covering the entire task.

Transfer from AVS to HO Tests. AVS testing did not produce any great improvement in subsequent HO performance when transfer was assessed for the breechblock tests. Since no feedback is supplied following incorrect responses in the AVS tests (unlike the intrinsic feedback provided by HO testing), little learning would be expected in the AVS test situation. The AVS test does contain information on the proper sequence of performance steps, but examinees in the present sample apparently were not able to make any substantial use of this information to increase their performance knowledge.

Although the percentage of examinees passing HO tests was always larger than the percentage passing the corresponding AVS test, transfer cannot account for this difference in performance levels. Apparently, the AVS tests tend to be more difficult than the HO tests.

Lack of transfer suggests that AVS tests may be used to advantage in repeatedly assessing levels of individual readiness in units and the trend of retention loss over time following training. To the extent that HO tests produce learning, HO test results provide a biased assessment of readiness, since they do not reflect possible increment in performance produced by testing. Furthermore, repeated retesting of the same individuals cannot be used to determine the course of retention loss, since the degree of retention loss can be markedly reduced by repeated testing. Repeated AVS tests might not produce a similar effect, and this possibility should be tested in later research.

For unit assessment purposes it would also be important to determine whether some correction could be applied to AVS test results to produce an unbiased estimate of the HO pass rate. As it now stands, AVS test results will underestimate the level of HO performance in a unit.

Critical Performance Skills. Although tasks involving motor performance are generally believed to require skill, the results of the present studies confirm previous findings (Shriver & Foley, 1974) that machine-dependent procedural tasks require little skill. For nearly all critical items, knowledge of what to do, as indicated by an AVS test item, guaranteed a high probability of being able to perform the comparable HO step. The probability of HO error was markedly higher than that for the AVS item only for one step in the breechblock installation task. Additional analysis of the performance requirements for that step confirmed the presence of an element of skill. The predictability of HO performance was restored when errors on this item were removed from the count of critical errors.

The comparison of AVS and HO test performance on critical items appears to provide a useful empirical method for identifying skill elements in procedural tasks. When the knowledge of what to do is both necessary and sufficient for successful performance of a behavioral step, skill is not required. When knowledge is necessary, but not sufficient to guarantee successful performance, then skill is required. The latter indication should be followed up by detailed observation and analysis of the behavior to fully identify the nature of the skill to insure that the indication is not faulty or misleading.

When the nature of the skill has been identified along with the factors contributing to HO failure on the behavioral step, it should then be possible to develop a valid but brief HO test covering the task segment, including the skill step. The step should not be tested entirely in isolation, since the examinee should be given a portion of the task sufficient to fully reinstate the relevant contextual cues available to guide performance. If an appropriate simulator is available, a high-fidelity simulation may be used in place of actual equipment in testing the task segment.

The HO or simulated test of the skill step may then be combined with the AVS test to form a complete synthetic test for the task. Passing both the AVS test and the skill step would be required to pass the synthetic test.

Reliability and Validity of HO Testing. Interrater reliability was found to be consistently high when critical errors were correlated, whereas other measures (total errors and step errors) tended to have lower reliabilities. On this basis, critical error scores were used as the primary criterion of performance to validate AVS tests throughout the present research.

Using critical error measures, subsequent examination of the prediction of HO performance for the breechblock showed that the test-retest reliabilities were disappointingly low for HO data. For the breechblock removal task there was no relationship between performance on successive HO tests. Such results demonstrate that, even when the evaluators are experienced and capable of reliable scoring, a single HO test may not provide a reliable indication of future HO performance.

Observations of HO testing conducted by Army personnel revealed potentially serious validity problems in HO evaluation data. Unrealistically low failure rates may be obtained where standards are ignored or loosely interpreted by the examiner. This was observed in HO testing for the breechblock and machine gun tasks studied here and may be the case for many other tasks as well.

Heretofore, the reliability and validity of Army HO performance tests has received little formal attention. A HO performance test is uncritically regarded as providing virtually perfect indication of performance capability. The test is assumed to have construct validity by virtue of being based on a task analysis and an explicitly defined performance objective, complete with conditions and standards. The test is assumed to be reliable, since ability to perform a task is conceptualized as a all-or-nothing phenomenon, rather than a matter of degree with observed performance being a variable and probabilistic outcome imperfectly reflecting ability. The all-or-nothing conception grows from the criterion-referenced attributes of the test. The present results demonstrate that the use of criterion-referenced testing does not eliminate the necessity of determining the reliability and validity of tests implemented in field applications.

To an extent, reliability and validity problems may be generated by overemphasis on "GO/NO-GO" scoring and product orientation, both in the development of tests and in the training of test examiners. Score sheets given to HO test examiners to record test results typically provide space to report only an overall "GO/NO-GO" for each task. Standards may be omitted, even when some steps are listed to remind the examinees of the sequence of task performance.

Ordinarily, the HO test examiner is instructed to adopt a product orientation in scoring performance. He is told that it doesn't matter how the task is completed as long as it is completed within certain standards. However, the standards tend to be overlooked or relaxed when heavy emphasis is placed on the product of performance rather than the process. Grounds for failure such as fleeting safety errors or other minor errors that could damage the equipment may easily pass unobserved if the examiner does not have his full concentration focused on details of the process of performance. Thus, high pass rates may be obtained with HO tests, when at the same time careful examination of the process of performance indicates that the task standards frequently are not met. This situation should not be viewed as evidence of bad faith, laxness, or intentional bias on the part of regular Army test and evaluation personnel, but simply as a natural consequence of the scoring instruments and method of testing.

Improvements in HO performance evaluation might be achieved if examiners were reoriented toward observation of the process of performance in addition to the product, even though it is the performance product that is the primary interest. Process evaluation should be aided by a content-validated checklist, explicitly listing only the critical elements (rather than steps) of performance that are required to insure reliably repeatable HO performance. Self-corrected errors on critical elements should be grounds for failure, unlike present practices. When critical errors are corrected, performance still would be allowed to proceed, so that further critical errors could be identified for diagnostic purposes. Additional quantitative requirements, such as time, should be numerically recorded, and only later compared to cutoff points as a basis for the overall final "GO/NO-GO."

Aside from problems of reliability and bias in scoring, experience in the course of developing HO checklists shows that there are important obstacles to establishing the content validity of a particular performance process. Frequent inconsistencies were found among sources of task documentation, training and test procedures, and advice of SMEs. The task analysis methods and approach to content validation suggested in Tasks 1 through 3 of the AVS test development methodology may be helpful in reconciling discrepancies among various authoritative sources.

Key Methodological Factors

Several aspects of the methodology employed here and the proposed test development methodology appear to be crucial in the successful development and validation of AVS tests.

Performance Knowledge. The test should be based on a conceptualization of the elements of performance knowledge which are acquired during hands-on practice. By definition, such knowledge is present in the memory of the proficient examinee and is incomplete in the less-proficient examinee. Valid test items should be designed to be easily answerable by one who can remember how to do the task and obscure to those who cannot.

Critical Elements. The test items should focus on performance elements that are critical to task performance. It is not necessary to remember every detail of task performance to successfully complete a task. In low-skill, machine-dependent procedural tasks, there is opportunity to correct minor errors based on feedback from the behavior and response of the machinery. For example, knowledge of the orientation of a part may not be essential for an assembly task, since the part often will not "go in" if improperly oriented. A little time is lost, but the part may be reoriented with little risk of total failure. Only under heavy time pressure would orientation knowledge prove important to save time.

In most cases, only safety errors, errors likely to produce damage or malfunction, or errors which do not provide feedback or only much delayed feedback should be considered crucial. In the latter case, the error will either not be discovered or will be discovered after many subsequent steps, so that many steps will have to be retraced or repeated, with a substantial loss in time.

Procedural Continuity. AVS tests should be designed to maintain a sense of continuity in the procedure. Performance of procedural tasks appears to be heavily dependent on contextual cues arising from prior performance steps. These contextual cues provide the stimuli for recall of what to do next. If the examinee doesn't know exactly where he is in the procedure, he will frequently be confused about what comes next. AVS test items presented out of context might easily be answered incorrectly, even though they usually would be performed correctly. Attempts to reinstate the performance context by verbal instructions will probably not be as effective as actually going through successive steps in a series of test items that provide a representation of the visual cues occurring in the sequence of procedural steps.

The machine gun clearing test provides a good example of this problem. In this task, the safety is moved between the "fire" and "safe" positions in several different steps. Without going through the procedure stepwise, and thus knowing that a particular action has just been taken, it would be difficult to remember whether or not to move the safety next. Telling the examinee to imagine that the action has been taken does not reinstate the occurrence of the contextual cues in the same way that showing a picture of the action would simulate their occurrence.

Tryout and Revision. Repeated tryout and revision is a very important contributor to the validity of an AVS test. For many of the items developed, the original ideas about how to picture a performance element, how to state the question, what response alternative to use, etc., were found to require considerable revision as a result of tryouts. Even notions about what items are critical required revision. The final version of each test that was validated was always a substantial improvement over the first version.

Systematic tryouts force the developer to look closely at both AVS and HO performance to develop a better understanding of why errors occur in either test, to account for discrepancies between tests, and to discover inadequacies of the original behavioral analysis. Without the discipline of repeated tryout, AVS tests will not usually be valid, however carefully the other steps of the methodology are carried out.

Method of Validation. An important factor is the kind of HO criterion data used to validate the AVS test. The HO data should be gathered by specially trained personnel using a content-validated checklist which emphasizes observation of the same critical items of performance as the AVS test critical items. Although use of a checklist listing only critical items was suggested to aid HO testing for evaluation purposes, the complete checklist should be used when validating AVS tests. The complete checklist is more difficult to use, but provides a firmer basis for determining that all critical elements have been identified and included in the AVS test.

Methodological Limitations

The AVS test development methodology suggested here can be expected to be successful in producing a predictive test only for tasks like those investigated in this research; that is, machine-related, low-skill procedural tasks. Based on the results of Shriver and Foley (1974), successful application cannot be expected in variable-branching procedural tasks, such as alignment and troubleshooting, or to high-skill tasks, such as soldiering or tracking. Skill elements embedded within low-skill procedural tasks also cannot be successfully tested by AVS items, as results for the breechblock installation task showed. Thus, while AVS items may be used to test most task elements, they may have to be combined with a HO test, or other high-fidelity simulated test on one or more skill elements to form a synthetic test for the whole task.

Despite these limitations, the suggested development methodology can be expected to apply to a very large number of tasks, at least in the machine-ascendent combat-arms MOS. In armor MOS, for example, the (new) CMF 19 task lists have 61 common tasks, of which about 54% appear to be appropriate for AVS testing. About 64% of the MOS-specific tasks seem to be appropriate, ranging from 53% of 85 tasks for the 19D scout, to 77% of the 31 tasks for the 19F tank driver. A large proportion of tasks in organizational maintenance MOS should also be amenable to AVS testing.

Efficiency of Simulated Testing

The efficiencies to be gained through AVS testing require careful study. Major savings in the areas of equipment and examiner personnel can be expected given the relative costs of audiovisual and military equipment, and the group-administration of AVS tests. Based on the present data, the necessity for 48.9% of the HO tests for the breechblock, and 55.3% of the HO tests for the machine gun might be avoided by initial screening with the AVS tests.

Examinee time is not so clearcut, efficiency depending to a large extent on how the AVS tests are combined with alternative testing and retesting procedures to form a full-performance screening system. Methods for evaluating the cost efficiency of pretesting systems for MOS 11B have been examined by Hiller (1977). Hiller's methods of analysis can be used easily to develop similar cost-efficiency models applicable to armor MOS. Unfortunately, the present research was completed prior to the appearance of Hiller's work, so that the data required to carry out the analysis were not obtained.

The AVS tests developed for the breechblock and machine gun both require testing time longer than that required to HO test one person. Thus, AVS testing would involve increased testing time per individual. This time may be partly or completely recovered from administrative time now wasted, such as waiting time spent in line or time required to travel between testing stations. Detailed study of queuing network models is required to determine the optimal structure of screening systems to minimize expenditures of training and testing time, along with personnel and equipment resources.

Implementation of AVS Testing

Screening systems based on AVS tests might be useful in both institutional and unit training settings. In institutional settings, group testing could be used to determine individual needs for remedial training prior to end-of-cycle or mid-cycle tests. If the AVS tests are based on the suggested test development methodology and, in addition, are thoroughly validated by procedures similar to those used in the present study, a substantial improvement on the quality of training output could result. It can be anticipated that the major factor producing a positive impact would be the identification of critical performance elements. Increased emphasis on critical elements in original training, remedial training, and testing should have an impact on trainee ability to perform critical tasks at their first duty assignment.

AVS tests could also be a valuable addition to the materials supporting individual training in units. AVS tests can usefully supplement or replace HO pretesting and posttesting to determine qualification on Soldiers Manual tasks. A considerable share of the Tank Crewman Gunnery Skills Test (TCGST) could also be covered by AVS tests.

In high-density MOS, the slide-tape format and group testing should continue to provide the most effective media for use in units. In low-density MOS, or for individualized instructional systems such as TEC, it may be advantageous to develop printed forms of the AVS test, with line-graphic visuals like those recommended for ITDT materials replacing the photographs used in the AVS test slides. If the line-graphic visuals are well prepared, little significant reduction in test validity should result from this substitution. Printed forms should reduce the load on unit audiovisual equipment and expenses associated with the reproduction and maintenance of slide-tape materials. The relative advantages and disadvantages of simulated testing with line-graphic visuals should be compared to the slide-tape medium in future research.

REFERENCES

Army Training Study (ARTS). Fort Knox Systems Work Team. The Learning and Retention of Basic Armor Skills Within the Institution. Draft Study Report. Fort Knox, Ky., May 1978.

Camilli, G., & Hopkins, K. D. Applicability of Chi-Square to 2x2 Contingency Tables With Small Expected Cell Frequencies. Psychological Bulletin, 1978, 85, 163-167.

Cockrell, J. T. Television as Stimulus Input in Synthetic Performance Testing. Alexandria, Va.: U.S. Army Research Institute, Technical Paper 303, August 1978.

Crowder, N., Morrison, E. J., & Demaree, R. G. Proficiency of Q-24 Radar Mechanics: VI. Analysis of Intercorrelations of Measures. (AFPTRC-TR-54-127) Lackland AFB, Tex.: Air Force Personnel and Training Research Center, 1954. AD 62115

Engel, J. D. Development of a Work Sample Criterion for General Vehicle Mechanic. HumRRO Tech Rep 70-11. Alexandria, Va.: Human Resources Research Organization, July 1970a.

Engel, J. D. An Approach to Standardizing Human Performance Assessment. HumRRO Professional Paper 26-70. Alexandria, Va.: Human Resources Research Organization, October 1970b.

Engel, J. D., & Rehder, R. J. A Comparison of Correlated Job and Work Sample Measures for General Vehicle Repairmen. HumRRO Tech Rep 70-16. Alexandria, Va.: Human Resources Research Organization, October 1970.

Foley, J. P., Jr. Evaluating Maintenance Performance: An Analysis. Wright-Patterson AFB, Ohio: Advance Systems Division, October 1974.

Glaser, R., & Kalus, D. J. "Proficiency Measurement: Assessing Human Performance," in Psychological Principles in System Development. R. M. Gagne (Ed.). New York: Holt, Rinehart and Winston, Inc., 1962.

Grings, V. W., Rigney, J. W., Bond, N. A., & Summers, S. A. A Methodological Study of Electronic Troubleshooting Skill: II. Intercomparisons of the MASTS Test, a Job Sample Test, and Ten Reference Tests Administered to Fleet Electronics Technicians. (Navy Technical Report 10). Department of Psychology, University of Southern California, August 1953.

Hiller, J. H. A Methodology for Estimating the Cost-Effectiveness of Alternative Pretests. Paper presented at Military Test Association Conference, 17-21 October 1977.

Kendall, M. G. Rank Correlation Methods. 4th ed. London: Charles Griffin and Co., Ltd., 1975.

Occhialini, N., Jr. Research Study: The Use of Qualification Tests as Performance Tests for Enlisted Combat MOS Evaluation. U.S. Army Enlisted Evaluation Center Research Study No. 162. Fort Benjamin Harrison, Ind.: U.S. Army Enlisted Evaluation Center, June 1972.

Osborn, W. C. An Approach to the Development of Synthetic Performance Tests for Use in Training Evaluation. HumRRO Professional Paper 30-70. Alexandria, Va.: Human Resources Research Organization, December 1970.

Osborn, W. C., Campbell, R. C., & Ford, J. P. Handbook of Development of Skill Qualification Tests. HumRRO Final Report FR-WD-(KY)-77-1. Alexandria, Va.: Human Resources Research Organization, January 1977.

Osborn, W. C., & Ford, J. P. Research on Methods of Synthetic Performance Testing. HumRRO Final Report FR-CE(L)-76-1. Alexandria, Va.: Human Resources Research Organization, April 1976.

Shriver, E. L., & Foley, J. P., Jr. Evaluating Maintenance Performance: The Development and Tryout of Criterion Referenced Job Task Performance Tests for Electronic Maintenance. (AFHRL-TR-74-57(II) Part I). Brooks AFB, Tex.: Air Force Human Resources Laboratory, September 1974a.

Shriver, E. L., & Foley, J. P., Jr. Evaluating Maintenance Performance: The Development of Graphic Symbolic Substitutes for Criterion Referenced Job Task Performance Tests for Electronic Maintenance. (AFHRL-TR-74-57 (III)). Brooks AFB, Tex.: Air Force Human Resources Laboratory, November 1974b.

Shriver, E. L., Hayes, J. F., & Hufhand, W. R. Evaluating Maintenance Performance: A Video Approach to Symbolic Testing of Electronics Maintenance Tasks. (AFHRL-TR-74-57 (IV)). Brooks AFB, Tex.: Air Force Human Resources Laboratory, July 1974.

Siegel, S. Nonparametric Statistics for the Behavioral Sciences. New York: McGraw Hill Book Company, Inc., 1956.

Swezy, R. W., & Pearstein, R. B. Guidebook for Developing Criterion-Referenced Tests. Alexandria, Va.: U.S. Army Research Institute, August 1975.

U.S. Department of the Army. Report of the Board for Dynamic Training (Gorman Board). Washington, D.C., December 1971.

U.S. Department of the Army. Report of the Board of Inquiry of Army Logistics System (Brown Board). Washington, D.C., May 1966.

APPENDIX A. AVS TEST (LONG FORM) ON REMOVAL, DISASSEMBLY, ASSEMBLY, AND INSTALLATION OF THE 105MM MAIN GUN (M68) BREECHBLOCK MECHANISM

TEST DIRECTIONS

Good (morning/afternoon) men:

I am with the United States Army Research Institute located here at Ft Knox, Kentucky. This morning/afternoon you have been selected to participate in a research project that involves the development and use of simulated performance test to assess job task performance. Specifically what we are interested in finding out from this research, is how well you can perform on an audio-visual (slide) test about the machine gun as compared to how well you can perform on the actual equipment in a hands-on test. The AV-Slide test you will be given here today involves the M-68 (105mm) Main Gun Breechblock tasks of removal, disassembly, assembly and installation. The test will take approximately 30 minutes to complete, but before we start I want you to print your name and unit at the top right hand corner of the answer sheet in the space provided. (Pause)

During the next five minutes you will be instructed on how to take the AV-Slide test on the machinegun. After these instructions are finished, you will be given the opportunity to ask any question you might have about the test before we begin testing. Now listen up and pay close attention to what you are being asked to do. (Start program)

<u>After Instructions</u>:

1. Answer all questions. After doing so, tell them to answer the questions as quickly as they can so that they will not miss the next question.

2. Motivate them to try their best.

After Test:

1. Collect all answer sheets.

2. Hand out the training questionnaire and ask them to complete them as best as they can. In the remarks column, have them write down what they thought of the test. i.e., Was it hard or easy, liked it or didn't like it, was good or bad, etc.

Main Gun Breechblock Mechanism

Test Directions

In the breechblock test you are about to take, you will be shown a slide and then asked a question. The number of the question is shown in the display in front of you. The questions you will be asked will be of three types:

What part would you take action on?,

What action would you take?, or

What picture shows the result of that action?

Sometimes you will also be asked about the correct location for a part. Possible answers to the questions are the letters A, B, or C shown on the slides. After selecting your answer you are to do two things. First, press the button on the control panel that corresponds to the letter of your answer. A number will be shown on the <u>right side</u> of the display when you press the button. Second, press the start/stop button to record this answer. When you record your answer, the number of the next question will appear on the <u>left side</u> of the display. For example, question Number 1: Which part would you take action on first to disassemble the M219 machine gun? "A" shows the barrel and jacket assembly, "B" shows the cover, and "C" shows the charger assembly. Choose A, B, or C, press the corresponding button and then the start/stop button.

Go ahead and record your answer. (Pause)

For this question you should have pressed the "A" button and then the start/stop button. The number "2" should now be shown in the display.

The next question is Question Number 2: Which action would you take? A, B, and C show three ways to remove the barrel and jacket assembly. Choose A, B, or C, press the button, and the the start/stop button.

Go ahead and record your answer. (Pause) The number "3" should now be shown in the display. In this test, the number on the left of the display should always be the same as the number of the question you hear on the tape. If it isn't the same, tell the examiner before you record any more answers. He will stop the test, and help you to correct the problem. Now, listen carefully and answer these practice questions.

Question Number 3: Which part would you take action on next? (Pause) If you selected the letter "B", the cover, your answer was correct.

Question Number 4: Which part would you take action on to remove the cover? (Pause) the correct answer was "C".

Question Number 5: Which action would you now take on the cover latch rod? (Pause) The correct answer was "C". The number 6 should now be shown in the display. Do you have any questions?

In the breechblock test some questions will ask you to choose two parts or two actions. To answer you should press the button which tells the part or action that would come first. Record the first answer by hitting the start/stop button. Then you should press the button which tells the part or action that would come second. Again, press the start/stop button to record the second answer.

For example, Question Number 7: What two actions must you take to remove the guide rod? To do this you would push in on the guide rod to compress the spring and then rotate the guide rod clockwise to remove it. This requires answer C, and then B. Now to record both answers you should press the letter "C", press the start/stop button, then press the letter "B", and press the start/stop button again. Do it now. (Pause) Whenever a question requires two answers, be sure to press start/stop after the first answer <u>before</u> you press the second answer. If you happen to press both answers by mistake, press the clear button, and then make your answers. You can also use the clear button to change your answer to any question, if you have not yet pressed the start/stop button. To change your answer, simply press the clear button, and then put in the answer you want.

During the test you will have approximately 5 seconds to record your answer. After you press the start/stop button, you can not change your answer anymore. If at any time during the test you don't know the answer to a particular question, press the letter "D" and then the start/stop button to go on to the next question. If you have any question about how to take this test, please raise your hand now and the examiner will help you.

APPENDIX B. PERFORMANCE CHECKLIST (LONG FORM) FOR EVALUATING HANDS-ON TEST PERFORMANCE ON THE 105MM MAIN GUN (M68) BREECHBLOCK MECHANISM

TEST: REMOVING AND DISASSEMBLING BREECHBLOCK

NAME____________________ CODE__________ TOTAL TIME_______

SEQ NBR	TASK STEPS/ELEMENTS	PART	TOOL	LOCUS	ACTION	RESULT	OBSERVATIONS
1	CHECK SAFETY						
	Lift Up on Safety Release Lever	1 P	T	L	2 A	3 R	
2	CHECK BREECHBLOCK CRANKSTOP						
	See /Feel Position of Crankstop	4 P	T	L	A	5 R	
3	CHECK CHAMBER FOR AMMO						
	Depress Breech Operating Handle Plunger	6 P	T	L	7 A	R	
	Pull Back on Handle and Rotate Completely Down	P	T	L	8 A	9 R	
	Lift Up on Handle and Rotate Completely Forward	P	T	L	10 A	R	
	See /Feel Chamber for Ammo	P	T	L	A	R	
	Obtain Breechblock Closing Tool (RAM/EXTRACTOR)	P	T	L	A	R	
	Push Extractor(s) Forward with Tool	11 P	T	L	12 A	R	
	Replace Tool in Secure Position	P	T	L	A	R	
4	REMOVE FIRING PIN ASSEMBLY						
	Slide Retainer Lug Plunger to the Right	13,14 P	T	L	15 A	R	
	Push in on Retainer and Rotate Counterclockwise	P	T	L	16 A	R	
	Lift Off Retainer and Separate from Spring	17 P	T	L	A	R	
	Place Parts in Secure Position on Turret Floor	P	T	L	A	R	
	Obtain Screwdriver	P	18 T	L	A	R	
	Insert Screwdriver in Center of Retractor Guide	19 P	T	L	A	R	
	Pry Retractor Guide Assembly Forward	P	T	L	20 A	R	
	Lift Out Firing Pin	21 P	T	L	22 A	R	
	Lift Out Retractor Guide Assembly	23 P	T	L	A	R	
	Place Parts in Secure Position on Turret Floor	P	T	L	A	R	
	Replace Screwdriver in Secure Position	P	T	L	A	R	
5	INSTALL EYEBOLT SCREW						
	Unscrew Eyebolt from Stowed Position Near Gun	24 P	T	L	A	R	
	Screw Eyebolt into Center of Breechblock Until Tight	P	T	25 L	26 A	R	
	Backoff Eyebolt to Align with Breech	P	T	L	27 A	28 R	
6	INSTALL THE CHAIN HOIST						
	Obtain Chain Hoist	P	29 T	L	A	R	
	Connect Chain Hoist Hook to Hook on Turret Roof	P	T	30 L	A	R	
	Connect Chain Hoist Hook to Eyebolt Screw	31 P	T	L	A	R	
	Pull Back on Chain to Keep it Tight	P	T	L	32 A	R	
	Crank Chain Hoist Until Chain is Tightened	P	T	L	33 A	34 R	

* Performance elements corresponding to the long form AVS breechblock test are numbered.

NBR	TASK STEPS/ELEMENTS	P	T	L	A	R	OBSERVATIONS
7	RELEASE ADJUSTER TENSION						
	Obtain Spanner Wrench (and Screwdriver)	P	T	L	A	R	
	Place Spanner Wrench in Holes on Adjuster	P	T	L	A	R	TO BE DONE BY ASSISTANT
	Pull Back on Spanner Wrench and Hold	P	T	L	A	R	
	Insert Screwdriver on Adjuster Plunger and Depress	P	T	L	A	R	TO BE DONE BY ASSISTANT
	Let out on Spanner Wrench as Adjuster Rotates CCW	P	T	L	A	R	
	Remove Spanner Wrench (and Screwdriver)	P	T	L	A	R	
	Replace Tools in Secure Position	P	T	L	A	R	
8	RELEASE BREECHBLOCK CRANKSTOP						
	Obtain Allen Wrench	P	T	L	A	R	
	Insert Allen Wrench into Crankstop Hole	P	T	L	A	R	
	Push Up and Slide Crankstop Completely Forward	P	T	L	A	R	
	Remove Allen Wrench and Secure in Safe Position	P	T	L	A	R	
9	LOOSEN THE CHAIN						
	Pull Out on Directional Knob and Rotate CW	P	T	L	A	R	
	Pull Out on Chain to Keep it Tight	P	T	L	A	R	
	Crank Chain Hoist until Chain is Slack	P	T	L	A	R	
10	START BREECHBLOCK DOWNWARD MOVEMENT						
	Depress Breech Operating Handle Plunger	P	T	L	A	R	
	Pull Handle Back Until Breechblock Drops	P	T	L	A	R	
	Rotate Handle Completely Forward	P	T	L	A	R	
	Crank Chain Hoist Until Pivot Pin is Free of T-Slot	P	T	L	A	R	
11	REMOVE PIVOT PIN						
	Reach Under Breech and Push/Pull Out Pin	P	T	L	A	R	
	Place Pivot Pin in Secure Position on Turret Floor	P	T	L	A	R	
12	LOWER BREECH BLOCK						
	Crank Chain Hoist Until Breechblock Reaches Controller Cover	P	T	L	A	R	
	Pull Chain to Swing Breechblock Rearward while Cranking Chain Hoist	P	T	L	A	R	
	Crank Chain Hoist until Breechblock Rests on Turret Floor	P	T	L	A	R	
13	RELEASE THE CHAINHOIST						
	Crank Chain Hoist Until Hook is Loose in Eyebolt	P	T	L	A	R	
	Unhook Chain Hoist from Eyebolt Screw	P	T	L	A	R	
	(Place Chain to Left or Right of Main Gun)	P	T	L	A	R	
14	REMOVE EXTRACTORS						
	Lift Out and Up on Left or Right Extractor	P	T	L	A	R	
	Lift Out and Up on Remaining Extractor	P	T	L	A	R	
	Place Extractors in Secure Position on Turret Floor	P	T	L	A	R	

TIME COMPLETED_______________

NBR	TASK STEPS/ELEMENTS	P	T	L	A	R	OBSERVATIONS
	DISASSEMBLING BREECHBLOCK						
	REMOVE FIRING CONTACT GROUP						
1	REMOVE FIRING CONTACT PLATE						
	Obtain Screwdriver	P	76 T	L	A	R	
	Insert Screwdriver on Plunger and Depress	74,74 P	T	L 77	A	R	
	Rotate Plate Counterclockwise and Lift Off	P	T	L	A	R	
	Replace Screwdriver in Secure Position	P	T	L	A	R	
	Place Plate in Safe Position on Turret Floor	P	T	L	A	R	
2	REMOVE FIRING CONTACT PLUNGER						
	Lift Out Plunger From Recess	78 P	T	L 79	A	R	
	Place Plunger in Safe Position on Turret Floor	P	T	L	A	R	
3	REMOVE FIRING CONTACT WASHER						
	Lift Off Washer from Firing Contact	80 P	T	L 81	A	R	
	Place Washer in Safe Position on Turret Floor	P	T	L	A	R	
4	REMOVE FIRING CONTACT						
	Lift Out Contact from Recess	82 P	T	L 83	A	R	
	Place Contact in Safe Position on Turret Floor	P	T	L	A	R	
5	REMOVE FIRING CONTACT SLEEVE						
	Insert Finger into Sleeve and Lift Out	84 P	T	L 85	A	R	
	Place Sleeve in Safe Position on Turret Floor	P	T	L	A	R	
6	REMOVE FIRING CONTACT SPRING						
	Obtain Allen Wrench	P	T	L	A	R	
	Insert Into Recess and Pull Out Spring	86 P	T	L 87	A	R	
	Place Spring in Safe Position on Turret Floor	P	T	L	A	R	
	Replace Tool in Secure Position	P	T	L	A	R	TIME COMPLETED________
	REMOVE RETRACTOR DRIVER GROUP						
1	REMOVE RETRACTOR DRIVER						
	Obtain Allen Wrench	P	90 T	L	A	R	
	Insert into Screw and Rotate CCW until Loose	89 P	T	L 91	A	R	
	Lift Off Screw-Washer-Clamp and Driver	92,93,95 P	T	L 94	A 96	R	
	Place Parts in Safe Position on Turret Floor	P	T	L	A	R	
2	REMOVE RETRACTOR DRIVER SHAFT						
	Lift Out Shaft from Recess	97 P	T	L 98	A	R	
	Place Shaft in Safe Position on Turret Floor	P	T	L	A	R	
3	REMOVE RETRACTOR DRIVER SPRING						
	Insert Allen Wrench into Recess and Pull Out Spring	99 P	100 T	L 101	A	R	
	Place Spring in Safe Position on Turret Floor	P	T	L	A	R	
	Replace Allen Wrench in Secure Position	P	T	L	A	R	TIME COMPLETED________

TEST: ASSEMBLING AND INSTALLING THE BREECHBLOCK

NAME________________ CODE__________ TOTAL TIME______________

SEQ NBR	TASK STEPS/ELEMENTS	PART	TOOL	LOCUS	ACTION	RESULT	OBSERVATIONS
	INSTALL RETRACTOR DRIVER GROUP						
1	INSTALL RETRACTOR DRIVER SPRING						
	Pick Up Spring from Parts on Turret Floor	P	T	L	A	R	
	Insert Spring into Recess	P	T	L	A	R	
2	INSTALL RETRACTOR DRIVER SHAFT						
	Pick Up Shaft from Parts on Turret Floor	P	T	L	A	R	
	Insert Stem of Shaft into Spring in Recess	P	T	L	A	R	
3	ASSEMBLE LOCKWASHER AND SCREW						
	Pick Up Lockwasher and Allen Screw	P	T	L	A	R	
	Insert Lockwasher onto Allen Screw	P	T	L	A	R	
4	INSTALL RETRACTOR DRIVER						
	Pick up Driver from Parts on Turret Floor	P	T	L	A	R	
	Place Base of Driver on Shaft and Lower in Position	P	T	L	A	R	
5	INSTALL RETRACTOR DRIVER CLAMP						
	Pick up Clamp from Parts on Turret Floor	P	T	L	A	R	
	Place Clamp onto Driver with Muzzle End Towards Face of Breech	P	T	L	A	R	
6	INSTALL LOCKWASHER AND SCREW						
	Align Hole in Breechblock with Hole in Driver and Clamp	P	T	L	A	R	
	Insert Screw and Hand Tighten	P	T	L	A	R	
	Obtain Allen Wrench	P	T	L	A	R	
	Insert into Screw and Tighten Securely	P	T	L	A	R	
	Replace Tool in Secure Position	P	T	L	A	R	TIME COMPLETED__________
	INSTALL FIRING CONTACT GROUP						
1	INSTALL FIRING CONTACT SPRING						
	Pick Up Spring from Parts on Turret Floor	P	T	L	A	R	
	Insert Spring into Recess	P	T	L	A	R	
2	INSTALL FIRING CONTACT SLEEVE						
	Pick Up Sleeve from Parts on Turret Floor	P	T	L	A	R	
	Insert into Recess with Open-End Up	P	T	L	A	R	
3	INSTALL FIRING CONTACT						
	Pick up Contact from Parts on Turret Floor	P	T	L	A	R	
	Insert into Sleeve with Larger Tip-End Up	P	T	L	A	R	
4	INSTALL FIRING CONTACT WASHER						
	Pick Up Washer from Parts on Turret Floor	P	T	L	A	R	
	Insert Over Top of Firing Contact	P	T	L	A	R	
5	INSTALL FIRING CONTACT PLUNGER						
	Pick Up Plunger from Parts on Turret Floor	P	T	L	A	R	
	Insert into Spring with Tip-End Up	P	T	L	A	R	
6	INSTALL FIRING CONTACT PLATE						
	Pick Up Plate from Turret Floor	P	T	L	A	R	
	Align Arrow on Plate with Arrow on Breechblock	P	T	L	A	R	
	Push Plate Down onto Components and Rotate Pully CW	P	T	L	A	R	

TIME COMPLETED__________

NBR	TASK STEPS/ELEMENTS	P	T	L	A	R	OBSERVATIONS
	INSTALL BREECHBLOCK						
1	**INSTALL EXTRACTORS**						
	Pick Up Extractors from Parts on Turret Floor	31 P	T	L	A	R	
	Insert Left or Right Extractor onto Pivots in Breech Ring	32 P	T	33 L	34 A	R	
	Insert Remaining Extractor onto Pivot in Breech Ring	P	T	L	35 A	36 R	
2	**INSTALL THE CHAIN HOIST**						
	Connect Chain Hoist Hook to Eyebolt Screw in Breechblock	P	T	L	A	R	
	Pull Out on Chain Hoist Direction Knob and Rotate CCW	P	T	L	A	R	
	Pull Back on Loose Chain to Keep It Tight	37 P	T	L	38 A	R	
	Crank Chain Hoist Until Chain is Tight	P	T	L	39,40 A	R	
3	**RAISE THE BREECHBLOCK INTO BREECH RING**						
	Crank Chain Hoist While Keeping Chain Straight	P	T	L	A	R	
	Guide Breechblock over Controller Cover	P	T	L	A	R	
	Guide Breechblock into Breech Ring	P	T	L	A	R	
	Stop Cranking Chain Hoist when Breechblock Contacts Plungers	P	T	L	A	41 R	
4	**DEPRESS THE PLUNGERS**						
	Obtain a Screwdriver	P	42 T	L	A	R	
	Depress Left or Right Plunger while Cranking Chain Hoist	43 P	T	L	44,45 A	R	
	Depress Remaining Plunger while Cranking Chain Hoist	P	T	L	46,47 A	R	
	Replace the Screwdriver in Safe Position	P	T	L	A	R	
5	**RAISE THE BREECHBLOCK**						
	Crank Chain Hoist Two Clicks and Stop	P	T	L	A	48 R	
6	**INSTALL PIVOT PIN**						
	Pick Up Pivot Pin from Parts on Turret Floor	49 P	T	L	A	R	
	Insert Pin Midway into Breechblock Crank	P	T	L	A	51 R	
7	**RAISE BREECHBLOCK CRANK PIVOT INTO T-SLOT**						
	Crank Chain Hoist while Guiding Pivot into Breechblock T-Slot	52,53 P	T	54,55 L	A	R	
	Stop Cranking Chain Hoist when Breechblock Contacts Tip of Extractors	P	T	L	A	56 R	

NPN	TASK STEPS/ELEMENTS	P	T	L	A	R	OBSERVATIONS
8	TRIP EXTRACTORS						
	Obtain a Screwdriver	P	T	L	A	R	
	Push Forward on Left or Right Extractor while Cranking Chain Hoist	57 P	T	58,59 L	A	R	
	Push Forward on Remaining Extractor while Cranking Chain Hoist	P	T	60,61 L	A	R	
	Replace Screwdriver in Safe Position	P	T	L	A	R	
9	RAISE BREECHBLOCK TO CLOSED POSITION						
	Crank Chain Hoist until Breechblock Align with Top Edges of Breech	62 P	T	63,64 L	A	65 R	
10	CLOSE BREECH BLOCK CRANKSTOP						
	Reach Under and Slide Crankstop Completely Rearward	66 P	T	L	A	67 R	
11	APPLY TENSION TO ADJUSTER						
	Pick Up Spanner Wrench	P	69 T	L	A	R	
	Insert Wrench into Slots on Adjuster	68 P	T	L	A	R	
	Pull Back on Adjuster until Plunger enters First Recess	P	T	L	70 A	71 R	
	Remove Wrench and Place in Secure Position	P	T	L	A	R	
12	LOOSEN THE CHAIN						
	Pull Out on Directional Knob and Rotate CW	72 P	T	73,74 L	A	R	
	Pull Out on Chain to Keep It Tight	P	T	L	A	R	
	Crank Chain Hoist until Chain is Slack	P	T	L	A	75 R	
13	REMOVE CHAIN HOIST						
	Disconnect Chain Hoist Hook from Eyebolt Screw	76 P	T	L	77 A	R	
	Disconnect Chain Hoist Hook from Hook on Turret Roof	P	T	L	78 A	R	
	Replace Chain Hoist in Secure Position	P	T	L	A	R	
14	REMOVE EYEBOLT SCREW						
	Unscrew Eyebolt from Breechblock	79 P	T	L	80 A	R	
	Screw Eyebolt into Stow Position Until Tight	P	T	L	A	R	
15	INSTALL FIRING PIN ASSEMBLY						
	Pick Up Retractor Guide Assembly from Parts on Turret Floor	81,82 P	T	L	A	R	
	Insert Guide with Slot Up until Flush with Firing Pin Well	P	T	L	83 A	R	
	Pick Up Firing Pin, Spring and Retainer from Turret Floor	P	T	L	A	R	
	Insert Firing Pin into Firing Pin Well	84 P	T	L	85 A	R	
	Twist Spring into Grooves on Backside of Retainer	86 P	T	L	A	R	
	Insert into Firing Pin Well and align Retainer with Slots	P	T	L	87 A	R	
	Slide Plunger to Right and Push Retainer into Firing Pin Well	P	T	L	A	R	
	Twist Retainer CW Until It Locks in Position	P	T	L	88 A	R	
16	CHECK BREECHBLOCK INSTALLATION						
	Depress Breech Operating Handle Plunger	89,90 P	T	L	91 A	R	
	Pull Back on Handle and Rotate Completely Down	P	T	L	92 A	93 R	
	Lift Up on Handle and Rotate Completely Forward	P	T	L	94 A	R	
	Obtain Breechblock Closing Tool (RAM/EXTRACTOR)	P	95 T	L	A	R	
	Push Extractor(s) Forward with Tool	P	T	L	96 A	R	
	Replace Tool in Secure Position	P	T	L	A	R	TIME COMPLETED______

APPENDIX C. TRAINING QUESTIONNAIRE ON THE 105MM MAIN GUN (M68) BREECHBLOCK MECHANISM

In OSUT, you have learned how to perform four tasks on the main gun breechblock: (1) Removal; (2) Disassembly; (3) Assembly; and (4) Installation. We would like to know how much training or practice you have gotten on these tasks.

1. How many times did you do the task yourself?

TASK	Circle ONE number for each task.					Write in number if greater than 4.
Remove	0	1	2	3	4	______
Dissassemble	0	1	2	3	4	______
Assemble	0	1	2	3	4	______
Install	0	1	2	3	4	______

2. How many times did you watch another trainee doing the task?

TASK	Circle ONE number for each task.					Write in number if greater than 4.
Remove	0	1	2	3	4	______
Dissassemble	0	1	2	3	4	______
Assemble	0	1	2	3	4	______
Install	0	1	2	3	4	______

3. How many times did you watch an instructor doing the task to show you how?

TASK	Circle ONE number for each task.					Write in number if greater than 4.
Remove	0	1	2	3	4	______
Dissassemble	0	1	2	3	4	______
Assemble	0	1	2	3	4	______
Install	0	1	2	3	4	______

4. How much time did you spend on your own studying these tasks in the technical manual?

0 1 2 3 4 ____hours

5. Did you see a TV demonstration of these tasks? YES______ NO______

6. How many times did you see the TV demonstration?

1 2 3 4 Write in number if greater than 4. _____

Remarks:____

____

____

____

____

CODE NUMBER__________

APPENDIX D. RELATIONSHIPS BETWEEN AVS TEST (LONG FORM) PERFORMANCE AND HO PERFORMANCES

Table D-1

Relationship Between AVS Test (Long Form) Performance and Subsequent HO Test Performance for the 105mm Main Gun (M68) Breechblock Tasks

	HO Test Performance					
	Group A		Group B		Both	
Task	Fail	Pass	Fail	Pass	Fail	Pass
Removal						
AVS Pass	0	9	3	6	3	15
Borderline[1]	4	7	3	6	7	13
AVS Fail	7	3	4	4	11	7
Disassembly						
AVS Pass	0	26	1	22	1	48
Borderline[1]	0	4	0	3	0	7
AVS Fail	0	0	0	0	0	0
Assembly						
AVS Pass	1	3	4	12	2	15
Borderline[1]	6	6	3	6	9	12
AVS Fail	11	1	1	2	15	3
Installation[2]						
AVS Pass	1	14	1	12	2	26
Borderline[1]	3	6	1	6	4	12
AVS Fail	3	1	2	6	5	7

[1] One AVS test error in Borderline Group.

[2] Excludes skill element from scoring.

Table D-2

Relationship Between AVS (Long Form) and HO Test Performance Including or Excluding a Skill Element from Scoring the 105mm Main Gun (M68) Breechblock Installation Task

Task	HO Test Performance: Group A Fail	Group A Pass	Group B Fail	Group B Pass	Both Fail	Both Pass
	Skill Element Included					
Installation						
AVS Pass	9	6	4	7	13	13
Borderline[1]	5	0	2	5	7	5
AVS Fail	3	5	6	4	9	9
	Skill Element Excluded					
Installation						
AVS Pass	1	14	1	12	2	26
Borderline[1]	3	1	2	6	5	7
AVS Fail	3	6	1	6	4	12

[1]One AVS test error in Borderline Group

Table D-3

Relationship Between HO Test Performance and Prior AVS or HO Test Performance for the 105mm Main Gun (M68) Broechblock Tasks

Task		HO Test Performance: Group A Fail	Group A Pass		Group B Fail	Group B Pass
Removal						
	AVS Pass	0	9	HO Pass	5	8
	AVS Fail	11	10	HO Fail	5	8
Disassembly						
	AVS Pass	0	26	HO Pass	1	22
	AVS Fail	0	4	HO Fail	0	3
Assembly						
	AVS Pass	1	3	HO Pass	2	10
	AVS Fail	17	7	HO Fail	6	10
Installation[1]						
	AVS Pass	1	14	HO Pass	1	16
	AVS Fail	6	7	HO Fail	3	8

[1] Excluding skill element from scoring.

APPENDIX E. AVERAGE FREQUENCY OF VARIOUS TYPES OF PRACTICE REPORTED FOR 105MM MAIN GUN (M68) BREECHBLOCK TASKS, RELATED TO PERFORMANCE

Table E-1

Average Frequency[1] of Various Types of Practice Reported for 105mm Main Gun (M68) Breechblock Tasks, Related to HO Performance Without Prior AVS Test

Task and Type of Practice	HO Performance with No Prior AVS Test Pass	Fail	z[2]
Removal	n = 13	n = 13	
Hands-on practice	2.15	1.77	2.15[3]
Trainee observation	3.23	3.23	0.70
Instructor observation	1.23	1.46	-0.66
Total observation	6.69	6.46	0.63
Disassembly	n = 23	n = 3	
Hands-on practice	2.00	1.67	0.68
Trainee observation	3.04	4.67	-0.08
Instructor observation	1.39	1.33	0.30
Total observation	6.43	7.67	0.25
Assembly	n = 12	n = 16	
Hands-on practice	2.00	1.44	1.35
Trainee observation	3.17	2.88	0.41
Instructor observation	1.58	1.06	1.25
Total practice	6.75	5.38	1.28
Installation	n = 17	n = 11	
Hands-on practice	1.82	1.45	1.22
Trainee observation	3.24	2.64	1.08
Instructor observation	1.41	1.09	0.70
Total practice	6.47	5.18	1.08

[1] Mean values.

[2] Value of large sample Mann-Whitney U-test statistic.

[3] Significant with $p < .05$.

Table E-2

Average Frequency[1] of Various Types of Practice Reported for 105mm Main Gun (M68) Breechblock Tasks, Related to HO Performance After AVS Test

Task and Type of Practice	HO Performance Pass	Fail	z[2]
Removal	n = 34	n = 21	
Hands-on practice	2.15	1.90	0.88
Trainee observation	3.03	3.00	0.69
Instructor observation	1.09	1.76	-2.14[3]
Total Practice	6.38	[illegible]	-0.57
Disassembly	n = 54	n = 1	z[4]
Hands-on practice	2.04	3.00	--
Trainee Observation	3.00	4.00	--
Instructor observation	1.33	2.00	--
Total practice	6.44	9.00	--
Assembly	n = 30	n = 26	
Hands-on practice	1.70	1.69	0.14
Trainee observation	3.03	2.84	1.27
Instructor observation	1.17	1.35	-0.29
Total practice	5.90	5.88	0.85
Installation	n = 28	n = 28	
Hands-on practice	1.84	1.09	2.66[5]
Trainee observation	3.09	2.36	1.63
Instructor observation	1.29	1.09	0.46
Total practice	6.22	4.55	2.18[3]

[1] Mean values.

[2] Value of large sample Mann-Whitney U-test statistic.

[3] Significant with $p < .05$.

[4] Not computed because of imbalance in Pass-Fail group sizes.

[5] Significant with $p < .01$.

Table E-3

Average Frequency[1] of Various Types of Practice Reported for 105mm Main Gun (M68) Related to Performance on the AVS Test

Task and Type of Practice	AVS Performance Pass	Fail	z^2
Removal	n = 17	n = 38	
Hands-on practice	2.12	2.03	0.62
Trainee observation	3.35	2.97	0.28
Instructor observation	0.76	1.61	-2.92[3]
Total practice	6.24	6.61	-0.62
Disassembly	n = 49	n = 6	
Hands-on practice	2.06	2.00	0.03
Trainee observation	3.08	3.17	-0.76
Instructor observation	1.29	1.83	-0.96
Total practice	6.43	7.00	-0.61
Assembly	n = 17	n = 39	
Hands-on practice	1.47	1.79	-1.20
Trainee observation	2.71	3.05	-0.48
Instructor observation	1.00	1.36	-1.26
Total practice	5.18	6.21	-0.77
Installation	n = 28	n = 28	
Hands-on practice	1.82	1.57	1.15
Trainee observation	2.96	2.93	1.15
Instructor observation	1.39	1.11	1.63
Total practice	6.18	5.61	1.75

[1] Mean values.

[2] Value of large sample Mann-Whitney U-test statistic.

[3] Significant with $p < .01$.

APPENDIX F. METHODOLOGY FOR DEVELOPMENT OF AUDIOVISUAL SIMULATED PERFORMANCE TESTS

An outline of the suggested AVS Test Methodology is presented in Figure F-1. Each of the nine major tasks and requirements necessary to perform each task is described below.

TASK 1: CONDUCT BEHAVIORAL TASK ANALYSIS

The first task to be accomplished in developing an audio-visual simulated performance test for a given job task is to correctly identify the task procedure and behaviors required to perform the job task. Job description data such as that presented in individual Soldiers Manuals (SMs), Skill Qualification Tests (SQTs), Field Manuals (FMs), Technical Manuals (TMs), and Training Extension Course (TECs) lessons are primary resource materials to be used when conducing this particular analysis. Task analysis documentation may also be available from prior instructional system development efforts. In addition, instructor lesson plans and evaluator checklist materials should be reviewed to help define the job task requirements.

All of these source materials merely procide a starting point for the behavioral analysis. Comparison of any two sources will usually reveal that the task procedures outlined are inconsistent, inaccurate, incomplete, or insufficiently detailed. The main objective of the analysis at this stage should be to resolve discrepancies among sources, and to further develop the procedural description to the level of task detail required.

As a working hypothesis in conducting the analysis (at least for machine-dependent tasks), each distinct part, control or display that plays some part in the performance should be considered to require a separate behavior step at each occasion of its involvement. This

TASK 1: CONDUCT BEHAVIORAL TASK ANALYSIS
- Collect job task description data
- Identify task procedural requirements
- Identify task behavior requirements

TASK 2: DEVELOP PERFORMANCE CHECKLIST
- Format the performance checklist
- Specify steps in task procedure
- Specify behaviors in task steps

TASK 3: CONTENT VALIDATE PERFORMANCE CHECKLIST
- Conduct on-site data collection
- Analyze task behavior data
- Review task analyses data with SMEs
- Finalize performance checklist

TASK 4: IDENTIFY CRITICAL TASK BEHAVIORS
- Identify critical safety behaviors
- Identify critical equipment behaviors
- Identify critical task outcome behaviors

TASK 5: DEVELOP PICTORIAL PAPER-AND-PENCIL TEST MATERIALS
- Contruct multiple choice test questions
- Select pictorial multiple choice alternatives
- Structure total task test for continuity
- Prepare data collection instrument

TASK 6: PILOT-TEST PICTORIAL PAPER-AND-PENCIL TEST
- Design test plan
- Administer pictorial test
- Revise test materials
- Finalize pictorial test

TASK 7: DEVELOP SLIDE TEST MATERIALS
- Photograph task behavior requirements
- Paste-up prints for slide
- Prepare 35mm color slides

TASK 8: DEVELOP AUDIO TEST MATERIALS
- Record test directions and practice test
- Record multiple choice test questions
- Synchronize sound with slide test

TASK 9: PILOT TEST AV-SLIDE TEST MATERIALS.
- Design test plan
- Administer AV-Slide test
- Analyze test data
- Revise test materials
- Finalize AV-Slide test

Figure F-1. METHODOLOGY FOR DEVELOPMENT OF AUDIO-VISUAL SIMULATED PERFORMANCE TESTS level of detail will not usually be explicity represented in any existing procedural outline. It must be developed by clearly visualizing the process of performance in real-time temporal sequence. The procedures that are identified by this method should represent a sequence of behavioral steps ensuring near-optimal efficiency in performance of the task, while minimizing risks of task failure and safety hazards. With respect to each step, a tentative list of performance elements (part, tool, location, action or result) involved in the steps should also be developed. Careful identification of each behavioral step and associated elements will provide the data base essential for simulated performance test development.

TASK 2: DEVELOP PERFORMANCE CHECKLIST

The task procedure, behaviors, and elements identified in Task 1 define the specific performance requirements to be included in a checklist for hands-on evaluation. The requirement of Task 2 is to transcribe this information onto a useable format. This can be accomplished by listing the major segments of the job task procedure at the left margin of a paper and then listing each of the behavioral step required to carry out the procedure underneath and indented approximately five spaces to the right. In front of each procedure a box can be drawn for recording the sequence in which the segments of the task procedure are actually performed. At the right margin of the paper and across from each behavior within a procedural step, the letters P, T, L, A, R are to be recorded. A space should be left between the letters for later identification (circling) of critical performance elements. An example of a performance checklist is shown in Appendix B.

TASK 3: CONTENT VALIDATE PERFORMANCE CHECKLIST

The next task to be accomplished in developing a simulated performance test is to content validate the analysis developed from the job description data (Task 1). Several on-site visits should be made to observe and record actual performance of the job task requirement during both training and testing. From practical experience, approximately twenty such observations using the performance checklist would be sufficient to become task knowledgeable. The data collected during these visits should be analyzed to identify the trainee performance errors and behaviors most difficult to perform. The task analyst should also thoroughly master performance of the task by direct practice following the procedure currently taught in the institution or on the job. Based on observations and direct experience in performing the task, some differences between official task documentation sources, optimal procedures, and current training or testing procedures may emerge. These differences should be documented with reference to the relevant sources of data in publications, analyses, or observations. The performance checklist should then be revised to conform to current training practices. The test to be ultimately developed must match the training actually given to achieve content validity.

Approximately five subject matter experts (SMEs) should be selected to serve as an advisory committee to review the revised performance checklist and to evaluate the twenty records of task performance. Any errors detected in the checklist or differences of opinion expressed by the committee should be thoroughly discussed with errors corrected and suggested changes recorded for possible addition to the checklist. Where necessary, the task analyst should demonstrate alternative procedures under observation of the SMEs to clarify discrepancies requiring resolution. In some cases the SMEs may agree in recommending one procedure, while a different procedure is presented in training. Issues of this kind may have to be brought to the attention of authorities responsible for training, to be resolved before test development can proceed.

TASK 4: IDENTIFY CRITICAL TASK BEHAVIORS

This step in the suggested test development methodology should be performed first by the individual test developer and then jointly with the assistance and expertise of the SMEs used during Task 3. In both cases, a task behavior is required to meet at least one of the following three criteria in order to be identified as critical for successful task performance:

1. <u>Injury to personnel</u> may result if the task behavior is omitted, performed out of sequence, or performed incorrectly.

2. <u>Damage or malfunctioning of equipment</u> may result if the task behavior is omitted, performed out of sequence, or performed incorrectly.

3. <u>Failure to achieve task outcome</u> within the standards specified may result if the task behavior is omitted, performed out of sequence, or performed incorrectly. That is, occurrence of such an error should have a direct impact on the chances of completing the task within standards, acting to substantially reduce the probability of passing a HO test.

The third criterion is the most difficult to apply in practice, requiring considerable judgment by the analyst and SMEs. Behaviors should not be considered noncritical simply because they are easy to perform and have a low probability of error. If the consequences of an error would seriously jeopardize the successful completion of the task, the behaviors should be regarded as critical, however improbable the error on that step.

On the other hand, behaviors should not be regarded as critical simply because it is difficult, involving a high degree of motor control or skill, or a high probability of error. If an error provides immediate and obvious feedback giving adequate notivation of the occurrence of the error, or the step cannot be bypassed without error correction, and error correction is easy and rapid based on the feedback, the ultimate consequence of the error will probably not be serious. In such cases, the examinee will correct his error and performance will proceed after a slight delay. Where there is little obvious feedback, so that the step can be bypassed, and it is difficult to recover from the error, the consequences are likely to be serious.

Task conditions and standards should be examined carefully for clues to critical behaviors. For example, high skill items will often be critical in tasks with stringent time standards, since lack of skill will generally result in losses of time that cannot be tolerated.

Once any of the task behaviors for a given job requirement meet one or more of these three criteria, they should be identified as critical and circled on the performance checklist for easy recognition. Although all items on the checklist are to be checked when observed, only those which have been identified as critical will be compared with AVS test performance in subsequent test validation efforts.

TASK 5: DEVELOP PICTORIAL PAPER-AND-PENCIL TEST MATERIALS

Three steps are involved in accomplishing this task. First, a three alternative multiple choice test question must be constructed for each of the critical behaviors identified in Task 4. This should be done using a paper-and-pencil format with pictorial representations of each multiple choice alternative substituted for the verbal identifiers. Selection of the three pictorial choices for a critical task behavior should be based on the likelihood of their being chosen as the correct answer in task performance. Specific reference to the hands-on performance data collected in Task 1 and the content validation effort conducted in Task 2 should provide the necessary insights to make these selections. As for the pictures themselves, they should be taken using an instant print camera with black-and-white film, and "shot" from the perspective or point of view of the person required to perform the task. By following this method, the test developer can continue to take pictures until he is completely satisfied that he has captured the desired result. After all desired pictures have been taken, arrows should then be added to each photograph to illustrate any action or highlight any location or part not immediately identifiable from the picture alone. Print size should be sufficient to retain necessary visual details after photographic reproduction in Task 7. Test questions should then be written which are specific and avoid unnecessary reference to equipment nomenclature.

Second, a sense of task continuity is to be maintained in the test by including questions on all major performance segments that constitute the total task. This should be done by selecting several task behaviors that bridge the gaps between the critical task behaviors. As a rule of thumb, at least one question should be constructed for each alternate behavioral step in the procedure. Steps omitted can be mentioned in the question stem for the following item. A complete part, action, and result question sequence should be prepared when omission of elements might lead to confusion about the sequence being followed. Task behaviors selected for the test should be constructed in the same manner and format as were the critical task behaviors, so that the critical items are not superficially distinguishable from noncritical items.

The third and final step in this task is to develop a paper-and-pencil data collection instrument for recording trainee test responses. A consecutive numbering scheme with the letters A, B, C, and D listed directly across from each number with sufficient space to circle their choice should be adequate. The first three letters (A, B, C) would be used by the trainee to identify his choice of answer from those available in the multiple choice question, while the letter D would be used by the trainee to record a "don't know" response. In preparing the data collection form, sufficient space should be left available for recording administrative information such as name, rank, company, test date, performance scores, etc. The particular format of the instrument is dictated by the task requirement and is left up to the creative skills of the test developer. For an example, refer to Appendix B.

TASK 6: PILOT-TEST PICTORIAL PAPER-AND-PENCIL TEST

Using the test materials developed in Task 5, the next task is to pilot-test the pictorial paper-and-pencil multiple choice test. Approximately ten trained and untrained personnel randomly selected from the test population should be given the test individually. Trainees not completely trained on the job task requirement should not be included in the sample of trained personnel to be selected. When an trained person makes an error, he should be asked to explain his choice, and his responses should be recorded for later review. In a similar fashion, untrained individuals should be asked about correct choices. After all testing has been completed and the results tabulated, analyze the data and make whatever modifications and revisions considered necessary to improve the test. Statistical techniques recommended by Swezy and Pearlstein (1975) should be used to process item data. A general rule of thumb, a test is considered acceptable if trained personnel do better than untrained personnel on each test question. If this is not the case, revise the question(s) and conduct a second pilot-test to include the revisions. Critical items should undergo the most rigorous scrutiny in this process. The cycle of test, revise, and retest is to be repeated as often as necessary until the finalized verison of the test meets the acceptability criteria.

TASK 7: DEVELOP SLIDE TEST MATERIALS

This task in the test development methodology requires the professional assistance of a skilled photographer and a training aid developer. With the assistance of a photographer each pictorial alternative "shot" in the finalized version of the paper-and-pencil test can now be professionally photographed. Make certain that any picture which is not of an acceptable quality because of lighting, contrast, angle, etc. is "reshot" until a quality black and white print is produced. With the assistance of the training aid developer, these prints should then be crimped at each corner and arrows added as necessary to illustrate actions or highlight a location or part not clearly identifiable. When this task is finished, the prints should then be pasted onto (15 x 20 inch) colored background material for photographing. Make certain that the location of each print is exactly the same as pictured in the original paper-and-pencil test. Using Leroy or rub-on lettering, identify each multiple-choice alternative. Each letter should be about one inch high, capitalized and centered one inch below each print. The next and final step in this process is to have the photographer prepare at least three 35mm color slides of each test question. Two complete sets of the slide test questions can be used for piloting and validating the test while the third test set remains available for making duplicate copies.

TASK 8: PREPARE AUDIO-TAPE TEST MATERIALS

To accomplish this task, record the test questions developed during Task 5 onto one side of a thirty, sixty or ninety minute audio cassette tape. Again, use whatever professional services are available to produce these tapes. In most cases, these audio tape recordings can be synchronized with the slides developed in Task 7, and the entire test programmed to operate automatically. If test directions and practice test questions are to be used to familiarize the trainees with the testing procedure and equipment, they too should be professionally developed and recorded. In both the practice and actual test, allow approximately ten seconds for the trainee to respond between questions. More precise time allocations can be made later based on the results of the initial AVS pilot test.

TASK 9: PILOT-TEST THE AVS TEST

The accomplishment of this task parallels the performance requirements specified to accomplish Task 6. The only exception here is that the test should be administered to a group of ten trained and ten untrained personnel from the test population in addition to the individual test administrations. Tryout of group testing provides a check on the adequacy of test directions and administrative procedures in the group instruction. Data collected and tabulated for both the individual and group performance testing should be analyzed separately, but the results used collectively to determine the need for additional revision and retesting. As before, more trained than untrained personnel must pass each critical test question in order for the AVS test to be considered acceptable. Since testing of highly similar materials has already taken place during Task 6 only minor modifications, if any, should be anticipated.

APPENDIX G. AVS TEST (SHORT FORM) FOR PERFORMANCE OF 105MM MAIN GUN (M68) BREECHBLOCK TASKS

TEST DIRECTIONS

Good (morning/afternoon) men:

I am with the United States Army Research Institute located here at Ft Knox, Kentucky. This (morning/afternoon) you have been selected to participate in a research project that involves the development and use of a simulated performance test to assess job task performance. Specifically, what we are interested in finding out from this research is how well you can perform on an audio-visual (slide) test about the main gun breechblock as compared to how well you can perform on the actual equipment in a hands-on test. The AV-Slide test you will be given here today involves the M68 (105mm) Main Gun Breechblock tasks of removal, disassembly, assembly and installation. The test will take approximately 30 minutes to complete, but before we start I want you to print your name and unit at the top right hand corner of the answer sheet in the space provided. (Pause)

During the next five minutes you will be instructed on how to take the AV-Slide test on the breechblock. After these instructions are finished, you will be given the opportunity to ask any question you might have about the test before we begin testing. Now listen up and pay close attention to what you are being asked to do.

(Start program)

<u>After Instructions</u>:

1. Answer all questions. After doing so, tell them to answer the questions as quickly as they can so that they will not miss the next question.

2. Motivate them to try their best.

After Test:

1. Collect all answer sheets.

2. Hand out the training questionnaire and ask them to complete them as best as they can. In the remarks column, have them write down what they thought of the test, i.e., was it hard or easy, did you like it or not, wat it a good test or bad, etc.

MAIN GUN BREECHBLOCK TEST

Test Directions

In the breechblock test you are about to take, you will be shown a slide and then asked a question. The number of the question will always be presented prior to each question. The questions you will be asked will be of three types:

What part would you take action on?

What action would you take?, or

What picture shows the result of that action?

Possible answers to the questions are the letters A, B, or C shown on the slides. After selecting your answer you are to do two things. First, find the number on the answer sheet that corresponds to the number of the question being asked. Second, circle the letter on the answer sheet that corresponds to your answer. To demonstrate how the breechblock test is set up, we have put together a series of practice questions on the M219 machine gun.

For example, Practice Question Number 1. Which part would you take action on first to disassemble the M219 machine gun? "A" shows the barrel and jacket assembly, "B" shows the cover, and "C" shows the charger assembly. Choose A, B, or C, find the number 1 under "Practice Questions" on the answer sheet, and then circle your answer. If you don't know, circle the letter D. Go ahead and record your answer.

For this question you should have circled the letter "A" opposite the number 1 under practice questions.

Practice Question Number 2. Which action would you take to remove the barrel and jacket assembly? A, B, and C show three possible ways to remove the barrel and jacket assembly. Choose A, B, or C, find the number of the practice question on the Answer sheet and then circle your answer. Again, if you don't know the answer to the question, circle the letter D. Go ahead and record your answer. (Pause) For this question the letter C was correct.

Now listen carefully and answer the remaining practice questions. Practice Question Number 3. After removing the barrel and jacket assembly which part would you take action on next? (Pause) If you circled the letter "B" the cover, your answer was correct.

Practice Question Number 4. Which part would you take action on to remove the cover? (Pause) The correct answer here was "C".

Practice Question Number 5. Which action would you take on the cover latch rod to remove the cover? (Pause) The correct answer here was "C".

In the breechblock test you are about to take, some questions will ask you to choose two parts or two actions. To record your answer you should simply circle the two letters that correspond to your answers. For example, Practice Question Number 6. What two actions would you take to remove the right guide rod and spring? To do this you would push in on the guide rod to compress the spring (the letter "C") and then rotate the guide rod counterclockwise (the letter "A") to remove it.

Both the letter "A" and the letter "C" should be circled on the answer sheet. Go ahead and record these answers. (Pause)

During the test you will have approximately 5 seconds to record your answer. If at any time during the test you don't know the answer to a particular question or you do not have enough time to respond, circle the letter "D" and go on to the next question.

If you have any question now about how to take this test, please raise your hand and the examiner will help you.

Paper and Pencil Copy

MAIN GUN BREECHBLOCK TEST QUESTIONS

1. Before you begin to remove and disassemble the breechblock, which part would you check out first?

*a. Main gun safety lever
b. Adjuster
c. Breechblock crankstop

2. Which picture shows the main gun safety in the safe position?

a. Safety lever's forward (up)
*b. Safety lever is rearward (down)
c.

3. Which part would you check out next?

a. Main gun safety lever
b. Adjuster
*c. Breechblock crankstop

4. Which picture shows the crankstop in the correct position?

*a. Crankstop is rearward (up)
b. Crankstop is forward (down)
c.

5. Which part would you take action on to complete the safety checks?

a. Safety release lever
*b. Breech operating handle
c. Eyebolt screw

6. With the safety checks completed which part would you take action on next?

a. Breech operating handle
b. Eyebolt screw receptable
*c. Firing pin assembly

7. After remvoing the firing pin assembly, which part would you take action on next?

a. Breech operating handle
b. Firing pin well
*c. Eyebolt screw

*Indicates correct answer.

8. After hooking the chain to the turret roof and eyebolt screw; which picture shows how tight you would crank the chainhoist?

*a. Tight
b. Loose
c. Moderately tight

9. With the chain tight, which part would you take action on next?

a. Breechblock crankstop
*b. Adjuster
c. Chain hoist crank

10. Which action would you take <u>first</u> to release spring tension on the adjuster?

a. Push forward
b. Depress plunger
*c. Pull rearward

11. With the adjuster tension released, which part would you take action on next?

a. Manual elevation handle
b. Chain hoist crank
*c. Breechblock crankstop

12. Which of these pictures shows the result of that action?

a. Crankstop is rearward (up)
*b Crankstop is forward (down)
c.

13. After reversing the direction of the chainhoist, which part would you take action on to start the breech downward?

*a. Breechblock operating handle
b. Chain hoist crank
c. Firing pin well

14. Once the breechblock starts downward, how far down would you lower the breechblock?

a. Partially
*b. Midway
c. Completely

15. Which action would you then take to remove the pivot pin?

a. Push up
*b. Push right
c. Pull down

16. Once the chainhoist is removed from the eyebolt screw, which action would you take next?

a. Unhook chain hoist
b. Lower breech operating handle
*c. Remove extractor

17. To disassemble the breechblock mechanism which part of the firing contact group would you take action on to unlock it?

a. Center circle of firing contact
b. Recessed edge of firing contact
*c. Plunger

18. Which two actions would you take?

*a. Rotate counterclockwise
*b. Depress plunger
c. Rotate clockwise

19. To disassemble the retractor driver group, which part would you take action on?

a. Retractor driver clamp
*b. Screw
c. Retractor driver

20. To assemble the breechblock mechanism which picture shows the order in which you would assemble the retractor driver group?

*a. Screw, clamp, driver, shaft, spring
b. Screw, clamp, spring, shaft, driver
c. Screw, shaft, clamp, spring, driver

21. After installing the spring, which action would you take to install the retraction driver shaft?

a. Large end of shaft down
*b. Large end of shaft up
c.

22. Which action would you take to install the retractor driver?

a. Align holes with L-shaped sides facing down
*b. Align holes with L-shaped sides facing up
c. Place L-shaped sides up

23. Which action would you take to install the retractor driver clamp?

a. Align so hole in clamp is closer to bottom of breechblock
b. Align so hole in clamp is closer to right side of breechblock
*c. Align so hole in clamp is closer to top of breechblock

24. Which picture shows the order in which you would assemble the firing contact group?

a. Spring, plunger, retainer, washer, shaft, sleeve
*b. Retainer, washer, shaft, sleeve, plunger, spring
c. Retainer, sleeve, shaft, washer, plunger, spring

25. Which action would you take to install the firing contact sleeve?

a. Insert with small tip-end up
*b. Insert with small tip-end down
c.

26. Which action would you take to install the firing contact?

a. Insert with small tip-end up
*b. Insert with small tip-end down
c.

27. After installing the washer and spring, which action would you take to install the plunger?

*a. Insert with small tip-end up
b. Insert with small tip-end down
c.

28. To install the breechblock into the breech rings, which extractor would you install in the right side of the breech?

a. Extractor with plunger at 11 o'clock
*b. Extractor with plunger at 1 o'clock
c.

29. Which action would you take?

a. Insert with plunger facing breech ring
*b. Insert with plunger facing opposite breech ring
c. Insert with plunger facing down toward breechblock cavity

30. After hooking up the chain hoist, how far up would you raise the breechblock?

a. Just off turret floor
*b. Up to tip of extractors
c. Up to top of breech ring

31. With the breechblock in this position, which part would you take action on next?

*a. Plunger
b. Tip of extractor
c. Eyebolt screw

32. Which two actions would you take to trip the right extractor plunger?

a. Depress the operating handle plunger
*b. Push forward on chain hoist crank
*c. Depress plunger with screw driver

33. After both plungers have been depressed, how far up would you raise the breechblock?

*a. Two clicks
b. Five clicks
c. Seven clicks

34. Which two actions would you take to guide the breechblock pivot pin into the T-slot?

*a. Push forward on chain hoist crank
*b. Check position of pivot pin in arm
c. Slide pivot pin to left of arm

35. Which two actions would you take to trip the right extractor?

a. Push rearward on extractor with screwdriver
*b. Push rearward on chain hoist crank
*c. Push forward on extractor with finger

36. With the breechblock now fully raised, which part would you take action on next?

a. Adjuster
b. Chain hoist
*c. Breechblock crankstop

37. After positioning the crankstop, which part would you now take action on?

*a. Adjuster
b. Chain hoist
c. Breechblock crankstop

38. Which action would you take to apply spring tension to the adjuster?

*a. Pull rearward
b. Push upward
c. Push forward

39. In which recess would you place the adjuster?

*a. Plunger is not visible
b. Half of plunger is visible
c. Plunger is fully visible

40. After removing the chainhoist and eyebolt screw, which part would you take action on next?

a. Breech operating handle
*b. Firing pin well
c. Eyebolt screw

41. Which action would you take to install the retractor guide assembly?

a. Insert with flat-end of guide forward and retractor down
*b. Insert with open-end of guide forward and retractor up
c. Insert with falt-end of guide forward and retractor up

42. Which action would you take to install the firing pin?

a. Insert with flat-end forward
*b. Insert with pointed-end forward
c.

43. With the breechblock fully installed, which part would you take action on next?

a. Safety rear
*b. Breech operating handle
c. Gunner's stab controls

44. If the breech closes, too slowly, during the function check, which part would you take action on?

a. Safety lever
*b. Adjuster
c. Breechblock crankstop

PERFORMANCE CHECKLIST (SHORT FORM) FOR EVALUATING HANDS-ON TEST PERFORMANCE ON THE 105MM MAIN GUN (M68) BREECHBLOCK MECHANISM*

TEST: REMOVING AND DISASSEMBLING BREECHBLOCK

NAME____________________________ CODE__________ TOTAL TIME______

SEQ NBR	TASK STEPS/ELEMENTS	PART	TOOL	LOCUS	ACTION	RESULT	OBSERVATIONS
1	CHECK SAFETY						
	Lift Up on Safety Release Lever	8 P	T	L	A	3 R	
2	CHECK BREECHBLOCK CRANKSTOP						
	See /Feel Position of Crankstop	5 P	T	L	A	4 R	
3	CHECK CHAMBER FOR AMMO						
	Depress Breech Operating Handle Plunger	5 P	T	L	A	R	
	Pull Back on Handle and Rotate Completely Down	P	T	L	A	R	
	Lift Up on Handle and Rotate Completely Forward	P	T	L	A	R	
	See /Feel Chamber for Ammo	P	T	L	A	R	
	Obtain Breechblock Closing Tool (RAM/EXTRACTOR)	P	T	L	A	R	
	Push Extractor(s) Forward with Tool	P	T	L	A	R	
	Replace Tool in Secure Position	P	T	L	A	R	
4	REMOVE FIRING PIN ASSEMBLY						
	Slide Retainer Lug Plunger to the Right	6 P	T	L	A	R	
	Push in on Retainer and Rotate Counterclockwise	P	T	L	A	R	
	Lift Off Retainer and Separate from Spring	P	T	L	A	R	
	Place Parts in Secure Position on Turret Floor	P	T	L	A	R	
	Obtain Screwdriver	P	T	L	A	R	
	Insert Screwdriver in Center of Retracter Guide	P	T	L	A	R	
	Pry Retractor Guide Assembly Forward	P	T	L	A	R	
	Lift Out Firing Pin	P	T	L	A	R	
	Lift Out Retracter Guide Assembly	P	T	L	A	R	
	Place Parts in Secure Position on Turret Floor	P	T	L	A	R	
	Replace Screwdriver in Secure Position	P	T	L	A	R	
5	INSTALL EYEBOLT SCREW						
	Unscrew Eyebolt from Stowed Position Near Gun	9 P	T	L	A	R	
	Screw Eyebolt into Center of Breechblock Until Tight	P	T	L	A	R	
	Backoff Eyebolt to Align with Breech	P	T	L	A	R	
6	INSTALL THE CHAIN HOIST						
	Obtain Chain Hoist	P	T	L	A	R	
	Connect Chain Hoist Hook to Hook on Turret Roof	P	T	L	A	R	
	Connect Chain Hoist Hook to Eyebolt Screw	P	T	L	A	R	
	Pull Back on Chain to Keep it Tight	P	T	L	A	2 R	
	Crank Chain Hoist Until Chain is Tightened	P	T	L	A	R	

* Performance elements corresponding to the short form AVS breechblock test are numbered.

NBR	TASK STEPS/ELEMENTS	P	T	L	A	R	OBSERVATIONS
7	RELEASE ADJUSTER TENSION						
	Obtain Spanner Wrench (and Screwdriver)	P	T	L	A	R	
	Place Spanner Wrench in Holes on Adjuster	9 P	T	L 10	A	R	TO BE DONE BY ASSISTANT
	Pull Back on Spanner Wrench and Hold	P	T	L	A	R	
	Insert Screwdriver on Adjuster Plunger and Depress	P	T	L	A	R	TO BE DONE BY ASSISTANT
	Let out on Spanner Wrench as Adjuster Rotates CCW	P	T	L	A	R	
	Remove Spanner Wrench (and Screwdriver)	P	T	L	A	R	
	Replace Tools in Secure Position	P	T	L	A	R	
8	RELEASE BREECHBLOCK CRANKSTOP						
	Obtain Allen Wrench	11 P	T	L	A	R	
	Insert Allen Wrench into Crankstop Hole	P	T	L	A	12 R	
	Push Up and Slide Crankstop Completely Forward	P	T	L	A	R	
	Remove Allen Wrench and Secure in Safe Position	P	T	L	A	R	
9	LOOSEN THE CHAIN						
	Pull Out on Directional Knob and Rotate CW	P	T	L	A	R	
	Pull Out on Chain to Keep it Tight	P	T	L	A	R	
	Crank Chain Hoist until Chain is Slack	P	T	L	A	R	
10	START BREECHBLOCK DOWNWARD MOVEMENT						
	Depress Breech Operating Handle Plunger	13 P	T	L	A	R	
	Pull Handle Back Until Breechblock Drops	P	T	L	A	R	
	Rotate Handle Completely Forward	P	T	L	A	14 R	
	Crank Chain Hoist Until Pivot Pin is Free of T-Slot	P	T	L	A	R	
11	REMOVE PIVOT PIN						
	Reach Under Breech and Push/Pull Out Pin	P	T	L 15	A	R	
	Place Pivot Pin in Secure Position on Turret Floor	P	T	L	A	R	
12	LOWER BREECH BLOCK						
	Crank Chain Hoist Until Breechblock Reaches Controller Cover	P	T	L	A	R	
	Pull Chain to Swing Breechblock Rearward while Cranking Chain Hoist	P	T	L	A	R	
	Crank Chain Hoist until Breechblock Rests on Turret Floor	P	T	L	A	R	
13	RELEASE THE CHAINHOIST						
	Crank Chain Hoist Until Hook is Loose in Eyebolt	P	T	L	A	R	
	Unhook Chain Hoist from Eyebolt Screw	P	T	L	A	R	
	(Place Chain to Left or Right of Main Gun)	P	T	L	A	R	
14	REMOVE EXTRACTORS						
	Lift Out and Up on Left or Right Extractor	P	T	L 16	A	R	
	Lift Out and Up on Remaining Extractor	P	T	L	A	R	
	Place Extractors in Secure Position on Turret Floor	P	T	L	A	R	

TIME COMPLETED______________

NBR	TASK STEPS/ELEMENTS	P	T	L	A	R	OBSERVATIONS
	DISASSEMBLING BREECHBLOCK						
	REMOVE FIRING CONTACT GROUP						
1	REMOVE FIRING CONTACT PLATE						
	Obtain Screwdriver	19 P	T	L	A	R	
	Insert Screwdriver on Plunger and Depress	P	T	L 18	A	R	
	Rotate Plate Counterclockwise and Lift Off	P	T	L	A	R	
	Replace Screwdriver in Secure Position	P	T	L	A	R	
	Place Plate in Safe Position on Turret Floor	P	T	L	A	R	
2	REMOVE FIRING CONTACT PLUNGER						
	Lift Out Plunger From Recess	P	T	L	A	R	
	Place Plunger in Safe Position on Turret Floor	P	T	L	A	R	
3	REMOVE FIRING CONTACT WASHER						
	Lift Off Washer from Firing Contact	P	T	L	A	R	
	Place Washer in Safe Position on Turret Floor	P	T	L	A	R	
4	REMOVE FIRING CONTACT						
	Lift Out Contact from Recess	P	T	L	A	R	
	Place Contact in Safe Position on Turret Floor	P	T	L	A	R	
5	REMOVE FIRING CONTACT SLEEVE						
	Insert Finger into Sleeve and Lift Out	P	T	L	A	R	
	Place Sleeve in Safe Position on Turret Floor	P	T	L	A	R	
6	REMOVE FIRING CONTACT SPRING						
	Obtain Allen Wrench	P	T	L	A	R	
	Insert Into Recess and Pull Out Spring	P	T	L	A	R	
	Place Spring in Safe Position on Turret Floor	P	T	L	A	R	
	Replace Tool in Secure Position	P	T	L	A	R	TIME COMPLETED________
	REMOVE RETRACTOR DRIVER GROUP						
1	REMOVE RETRACTOR DRIVER						
	Obtain Allen Wrench	19 P	T	L	A	R	
	Insert Into Screw and Rotate CCW until Loose	P	T	L	A	R	
	Lift Off Screw-Washer-Clamp and Driver	P	T	L	A	R	
	Place Parts in Safe Position on Turret Floor	P	T	L	A	R	
2	REMOVE RETRACTOR DRIVER SHAFT						
	Lift Out Shaft from Recess	P	T	L	A	R	
	Place Shaft in Safe Position on Turret Floor	P	T	L	A	R	
3	REMOVE RETRACTOR DRIVER SPRING						
	Insert Allen Wrench into Recess and Pull Out Spring	P	T	L	A	R	
	Place Spring in Safe Position on Turret Floor	P	T	L	A	R	
	Replace Allen Wrench in Secure Position	P	T	L	A	R	

TIME COMPLETED________

TEST: ASSEMBLING AND INSTALLING THE BREECHBLOCK

NAME________________________ CODE__________ TOTAL TIME______________

SEQ NBR	TASK STEPS/ELEMENTS		PART	TOOL	LOCUS		ACTION	RESULT	OBSERVATIONS
	INSTALL RETRACTOR DRIVER GROUP								
1	INSTALL RETRACTOR DRIVER SPRING								
	Pick Up Spring from Parts on Turret Floor	20	P	T	L		A	R	
	Insert Spring into Recess		P	T	L		A	R	
2	INSTALL RETRACTOR DRIVER SHAFT								
	Pick Up Shaft from Parts on Turret Floor	20	P	T	L	21	A	R	
	Insert Stem of Shaft into Spring in Recess		P	T	L		A	R	
3	ASSEMBLE LOCKWASHER AND SCREW								
	Pick Up Lockwasher and Allen Screw	20	P	T	L		A	R	
	Insert Lockwasher onto Allen Screw		P	T	L		A	R	
4	INSTALL RETRACTOR DRIVER								
	Pick up Driver from Parts on Turret Floor	20	P	T	L	22	A	R	
	Place Base of Driver on Shaft and Lower in Position		P	T	L		A	R	
5	INSTALL RETRACTOR DRIVER CLAMP								
	Pick up Clamp from Parts on Turret Floor	20	P	T	L		A	R	
	Place Clamp onto Driver with Muzzle End Towards Face of Breech		P	T	L	23	A	R	
6	INSTALL LOCKWASHER AND SCREW								
	Align Hole in Breechblock with Hole in Driver and Clamp		P	T	L		A	R	
	Insert Screw and Hand Tighten		P	T	L		A	R	
	Obtain Allen Wrench		P	T	L		A	R	
	Insert Into Screw and Tighten Securely		P	T	L		A	R	
	Replace Tool in Secure Position		P	T	L		A	R	TIME COMPLETED__________
	INSTALL FIRING CONTACT GROUP								
1	INSTALL FIRING CONTACT SPRING								
	Pick Up Spring from Parts on Turret Floor	24	P	T	L		A	R	
	Insert Spring into Recess		P	T	L		A	R	
2	INSTALL FIRING CONTACT SLEEVE								
	Pick Up Sleeve from Parts on Turret Floor	24	P	T	L	25	A	R	
	Insert into Recess with Open-End Up		P	T	L		A	R	
3	INSTALL FIRING CONTACT								
	Pick up Contact from Parts on Turret Floor	24	P	T	L	26	A	R	
	Insert into Sleeve with Larger Tip-End Up		P	T	L		A	R	
4	INSTALL FIRING CONTACT WASHER								
	Pick Up Washer from Parts on Turret Floor	24	P	T	L		A	R	
	Insert Over Top of Firing Contact		P	T	L		A	R	
5	INSTALL FIRING CONTACT PLUNGER								
	Pick Up Plunger from Parts on Turret Floor	24	P	T	L	27	A	R	
	Insert into Spring with Tip-End Up		P	T	L		A	R	
6	INSTALL FIRING CONTACT PLATE								
	Pick Up Plate from Turret Floor	24	P	T	L		A	R	
	Align Arrow on Plate with Arrow on Breechblock		P	T	L		A	R	
	Push Plate Down onto Components and Rotate Fully CW		P	T	L		A	R	

TIME COMPLETED__________

NBR	TASK STEPS/ELEMENTS	P	T	L	A	R	OBSERVATIONS
	INSTALL BREECHBLOCK						
1	INSTALL EXTRACTORS						
	Pick Up Extractors from Parts on Turret Floor	P	T	L	A	R	
	Insert Left or Right Extractor onto Pivots in Breech Ring	26 P	T	L 29	A	R	
	Insert Remaining Extractor onto Pivot in Breech Ring	P	T	L	A	R	
2	INSTALL THE CHAIN HOIST						
	Connect Chain Hoist Hook to Eyebolt Screw in Breechblock	P	T	L	A	R	
	Pull Out on Chain Hoist Direction Knob and Rotate CCW	P	T	L	A	R	
	Pull Back on Loose Chain to Keep It Tight	P	T	L	A	R	
	Crank Chain Hoist Until Chain is Tight	P	T	L	A	R	
3	RAISE THE BREECHBLOCK INTO BREECH RING						
	Crank Chain Hoist While Keeping Chain Straight	P	T	L	A	R	
	Guide Breechblock over Controller Cover	P	T	L	A	R	
	Guide Breechblock into Breech Ring	P	T	L	A	R	
	Stop Cranking Chain Hoist when Breechblock Contacts Plungers	P	T	L	A	30 R	
4	DEPRESS THE PLUNGERS						
	Obtain a Screwdriver	P	T	L	A	R	
	Depress Left or Right Plunger while Cranking Chain Hoist	31 P	T	L	32 A	R	
	Depress Remaining Plunger while Cranking Chain Hoist	P	T	L	A	R	
	Replace the Screwdriver in Safe Position	P	T	L	A	R	
5	RAISE THE BREECHBLOCK						
	Crank Chain Hoist Two Clicks and Stop	P	T	L	A	33 R	
6	INSTALL PIVOT PIN						
	Pick Up Pivot Pin from Parts on Turret Floor	P	T	L	A	R	
	Insert Pin Midway into Breechblock Crank	P	T	L	A	R	
7	RAISE BREECHBLOCK CRANK PIVOT INTO T-SLOT						
	Crank Chain Hoist while Guiding Pivot into Breechblock T-Slot	P	T	L	34 A	R	
	Stop Cranking Chain Hoist when Breechblock Contacts Tip of Extractors	P	T	L	A	R	

NBR	TASK STEPS/ELEMENTS	P	T	L	A	R	OBSERVATIONS
8	TRIP EXTRACTORS						
	Obtain a Screwdriver	P	T	L	A	R	
	Push Forward on Left or Right Extractor while Cranking Chain Hoist	P	T	L 36	A	R	
	Push Forward on Remaining Extractor while Cranking Chain Hoist	P	T	L	A	R	
	Replace Screwdriver in Safe Position	P	T	L	A	R	
9	RAISE BREECHBLOCK TO CLOSED POSITION						
	Crank Chain Hoist until Breechblock Align with Top Edges of Breech	P	T	L	A	R	
10	CLOSE BREECH BLOCK CRANKSTOP						
	Reach Under and Slide Crankstop Completely Rearward	36 P	T	L	A	R	
11	APPLY TENSION TO ADJUSTER						
	Pick Up Spanner Wrench	P	T	L	A	R	
	Insert Wrench into Slots on Adjuster	37,44 P	T	L	A	R	
	Pull Back on Adjuster until Plunger enters First Recess	P	T	L 38	A 39	R	
	Remove Wrench and Place in Secure Position	P	T	L	A	R	
12	LOOSEN THE CHAIN						
	Pull Out on Directional Knob and Rotate CW	P	T	L	A	R	
	Pull Out on Chain to Keep It Tight	P	T	L	A	R	
	Crank Chain Hoist until Chain is Slack	P	T	L	A	R	
13	REMOVE CHAIN HOIST						
	Disconnect Chain Hoist Hook from Eyebolt Screw	P	T	L	A	R	
	Disconnect Chain Hoist Hook from Hook on Turret Roof	P	T	L	A	R	
	Replace Chain Hoist in Secure Position	P	T	L	A	R	
14	REMOVE EYEBOLT SCREW						
	Unscrew Eyebolt from Breechblock	P	T	L	A	R	
	Screw Eyebolt into Stow Position Until Tight	P	T	L	A	R	
15	INSTALL FIRING PIN ASSEMBLY						
	Pick Up Retractor Guide Assembly from Parts on Turret Floor	40 P	T	L 41	A	R	
	Insert Guide with Slot Up until Flush with Firing Pin Well	P	T	L	A	R	
	Pick Up Firing Pin, Spring and Retainer from Turret Floor	P	T	L 42	A	R	
	Insert Firing Pin into Firing Pin Well	P	T	L	A	R	
	Twist Spring into Grooves on Backside of Retainer	P	T	L	A	R	
	Insert into Firing Pin Well and align Retainer with Slots	P	T	L	A	R	
	Slide Plunger to Right and Push Retainer into firing Pin Well	P	T	L	A	R	
	Twist Retainer CW Until It Locks in Position	P	T	L	A	R	
16	CHECK BREECHBLOCK INSTALLATION						
	Depress Breech Operating Handle Plunger	43 P	T	L	A	R	
	Pull Back on Handle and Rotate Completely Down	P	T	L	A	R	
	Lift Up on Handle and Rotate Completely Forward	P	T	L	A	R	
	Obtain Breechblock Closing Tool (RAM/EXTRACTOR)	P	T	L	A	R	
	Push Extractor(s) Forward with Tool	P	T	L	A	R	
	Replace Tool in Secure Position	P	T	L	A	R	TIME COMPLETED ________

MAIN GUN BREECHBLOCK TEST

Answer Sheet

NAME ______________________ UNIT ______________________

Practice Questions (Circle answer)

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D

FOR ADMINISTRATIVE USE

ST Score	RE	DI	AS	IN	HO Score	RE	DI	AS	IN
PF	___	___	___	___	PF	___	___	___	___
ER	___	___	___	___	ER	___	___	___	___

TEST QUESTIONS

Remove	Disassemble	Assemble	Install
1. A B C D	17. A B C D	20. A B C D	28. A B C D
2. A B C D	18. A B C D	21. A B C D	29. A B C D
3. A B C D	19. A B C D	22. A B C D	30. A B C D
4. A B C D		23. A B C D	31. A B C D
5. A B C D		24. A B C D	32. A B C D
6. A B C D		25. A B C D	33. A B C D
7. A B C D		26. A B C D	34. A B C D
8. A B C D		27. A B C D	35. A B C D
9. A B C D			36. A B C D
10. A B C D			37. A B C D
11. A B C D			38. A B C D
12. A B C D			39. A B C D
13. A B C D			40. A B C D
14. A B C D			41. A B C D
15. A B C D			42. A B C D
16. A B C D			43. A B C D
			44. A B C D

Table G-1

Relationship Between HO Test Performance and Prior AVS Test (Short Form) Performance for the 105mm Main Gun (M68) Breechblock Tasks

Task	HO Test Performance		Combined HO Test Performance	
	Fail	Pass	Fail	Pass
Removal				
AVS Pass	0	3		
Borderline[1]	2	0		
AVS Fail	4	1		
Disassembly				
AVS Pass	0	4	0	2
Borderline[1]	0	4	0	1
AVS Fail	1	1	6	1
Assembly				
AVS Pass	1	2		
Borderline[1]	0	1		
AVS Fail	4	2		
Installation				
AVS Pass	0	8	1	2
Borderline[1]	1	1	0	1
AVS Fail	0	0	4	2

[1] One AVS test error in Borderline groups for both individual and combined tests.

APPENDIX H. AVS TEST (SHORT FORM) ON CLEARING, DISASSEMBLY, ASSEMBLY, FUNCTION CHECK, AND STOPPAGE ON THE COAXIAL MACHINE GUN (M73/219)

M73 (Model 219) Machinegun Test

Test Directions

In the M73 (Model 219) Machine gun test you are about to take, you will be shown a slide and then asked a question. The number of the question will always be presented prior to each question. The questions you will be asked will be of three types:

What part would you take action on?

What action would you take?, or

What picture shows the result of that action?

Possible answers to the questions are the letters A, B, or C shown on the slides. After selecting your answer you are to do two things. First, find the number on the answer sheet that corresponds to the number of the question being asked. Second, circle the letter on the answer sheet that corresponds to your answer. To demonstrate how the Machine gun test is set up, we have put together a series of practice questions on the Main Gun Breechblock.

For example, Practice Question Number 1. Which part would you check out first prior to removing the breechblock? "A" shows the safety, "B" shows the adjuster and "C" shows the crankstop. Choose A, B, or C, find the number 1 under "Practice Questions" on the answer sheet, and then circle your answer. If you don't know, circle the letter D. Go ahead and record your answer. (Pause)

For this question you should have circled the letter "A" opposite the number 1 under practice questions.

Practice Question Number 2. Which action would you take to place the safety in the SAFE position? A, B, and C show three possible ways to perform this action. Choose A, B, or C, find the number of the practice question on the answer sheet and then circle your answer. Again, if you don't know the answer to the question, circle the letter D. Go ahead and record your answer. (Pause) For this question the letter B was correct.

Now listen carefully and answer the remaining practice questions. Practice Question Number 3. Which picture shows the safety in the safe position? (Pause) If you circled the letter "B" the cover, your answer was correct.

Practice Question Number 4. Which part would you check out next prior to removing the breechblock? (Pause) The correct answer here was "A".

Practice Question Number 5. Which picture shows the crankstop in the correct position? (Pause) The correct answer here was "A".

In the machine gun test you are about to take, some questions will ask you to choose <u>two</u> parts or <u>two</u> actions. To record your answer you should simply circle the two letters that correspond to your answers. For example, Practice Question Number 6. What <u>two</u> actions would you take to trip the right extractor? To do this you would push the extractor forward (the letter "C") and push forward on the chain hoist crank (the letter "B") to trip it. Both the letter "B" and the letter "C" should be circled on the answer sheet. Go ahead and record these answers. (Pause)

APPENDIX H. AVS TEST (SHORT FORM) ON CLEARING, DISASSEMBLY, ASSEMBLY, FUNCTION CHECK, AND STOPPAGE ON THE COAXIAL MACHINE GUN (M73/219)

M73 (Model 219) Machinegun Test

Test Directions

In the M73 (Model 219) Machine gun test you are about to take, you will be shown a slide and then asked a question. The number of the question will always be presented prior to each question. The questions you will be asked will be of three types:

What part would you take action on?

What action would you take?, or

What picture shows the result of that action?

Possible answers to the questions are the letters A, B, or C shown on the slides. After selecting your answer you are to do two things. First, find the number on the answer sheet that corresponds to the number of the question being asked. Second, circle the letter on the answer sheet that corresponds to your answer. To demonstrate how the Machine gun test is set up, we have put together a series of practice questions on the Main Gun Breechblock.

For example, Practice Question Number 1. Which part would you check out first prior to removing the breechblock? "A" shows the safety, "B" shows the adjuster and "C" shows the crankstop. Choose A, B, or C, find the number 1 under "Practice Questions" on the answer sheet, and then circle your answer. If you don't know, circle the letter D. Go ahead and record your answer. (Pause)

For this question you should have circled the letter "A" opposite the number 1 under practice questions.

Practice Question Number 2. Which action would you take to place the safety in the SAFE position? A, B, and C show three possible ways to perform this action. Choose A, B, or C, find the number of the practice question on the answer sheet and then circle your answer. Again, if you don't know the answer to the question, circle the letter D. Go ahead and record your answer. (Pause) For this question the letter B was correct.

Now listen carefully and answer the remaining practice questions. Practice Question Number 3. Which picture shows the safety in the safe position? (Pause) If you circled the letter "B" the cover, your answer was correct.

Practice Question Number 4. Which part would you check out next prior to removing the breechblock? (Pause) The correct answer here was "A".

Practice Question Number 5. Which picture shows the crankstop in the correct position? (Pause) The correct answer here was "A".

In the machine gun test you are about to take, some questions will ask you to choose <u>two</u> parts or <u>two</u> actions. To record your answer you should simply circle the two letters that correspond to your answers. For example, Practice Question Number 6. What <u>two</u> actions would you take to trip the right extractor? To do this you would push the extractor forward (the letter "C") and push forward on the chain hoist crank (the letter "B") to trip it. Both the letter "B" and the letter "C" should be circled on the answer sheet. Go ahead and record these answers. (Pause)

During the test you will have approximately 5 seconds to record your answer. If at any time during the test you don't know the answer to a particular question or you do not have enough time to respond, circle the letter "D" and go on to the next question.

If you have any question now about how to take this test, please raise your hand and the examiner will help you.

PAPER AND PENCIL COPY OF THE AVS TEST (SHORT FORM)

M73 (MODEL 219) MACHINE GUN TEST QUESTIONS

CLEARING

The M219 machinegun is loaded with a 20 round belt of ammunition. As the loader, your task is to clear the weapon.

1. Which part would you take action on first to clear the weapon?

   a. Disconnector ring
   b. Charger handle
   *c. Safety

2. Which action would you take on the safety?

   *a. Slide lever to right
   b. Slide lever to left
   c. Push lever up

3. Which picture shows the result of that action?

   *a. "F" shows
   b. "S" shows

4. Which part would you take action on next?

   a. Cover
   b. Cover latch rod
   *c. Charger handle

5. Which action would you take on the charger handle?

   a. Pull sideways
   b. Pull up
   *c. Pull back

6. Which part would you take action on now?

   a. Disconnector ring
   b. Charger handle
   *c. Safety

7. Which action would you take?

   a. Slide lever to right
   *b. Slide lever to left
   c. Push lever up

* Indicates correct answer.

8. Which part would you take action on next?

a. Cover
*b. Cover latch rod
c. Charger handle

9. Which action would you take to raise the cover?

*a. Push in on rod and lift up on cover
b. Pull back on disconnect ring and lift up on cover
c. Depress buffer support lever and lift up on cover

10. Which part would you take action on next?

a. Buffer support lever
*b. Ammo belt
c. Charger handle

11. Which part would you take action on now?

a. Cover
*b. Feed tray
c. Cover latch rod

12. Which action would you take to inspect the weapon?

a. Feel top of extractors
b. Feel inside of feed tray
*c. Feel inside of chamber

13. Which part would you take action on next?

a. Cover and feed tray
*b. Safety
c. Charger handle

14. Which picture shows the result of that action?

*a. "F" shows
b. "S" shows
c.

15. Which part would you take action on next?

a. Cover and feed tray
b. Charger handle
*c. Firing trigger

8. Which part would you take action on next?

 a. Cover
*b. Cover latch rod
 c. Charger handle

9. Which action would you take to raise the cover?

*a. Push in on rod and lift up on cover
 b. Pull back on disconnect ring and lift up on cover
 c. Depress buffer support lever and lift up on cover

10. Which part would you take action on next?

 a. Buffer support lever
*b. Ammo belt
 c. Charger handle

11. Which part would you take action on now?

 a. Cover
*b. Feed tray
 c. Cover latch rod

12. Which action would you take to inspect the weapon?

 a. Feel top of extractors
 b. Feel inside of feed tray
*c. Feel inside of chamber

13. Which part would you take action on next?

 a. Cover and feed tray
*b. Safety
 c. Charger handle

14. Which picture shows the result of that action?

*a. "F" shows
 b. "S" shows
 c.

15. Which part would you take action on next?

 a. Cover and feed tray
 b. Charger handle
*c. Firing trigger

M73 (MODEL 219) MACHINE GUN TEST QUESTIONS

DISASSEMBLY

As the loader, you have just cleared the M219 machine gun. Your task now is to disassemble the weapon for cleaning and lubrication.

1. Which part would you remove first?

   *a. Barrel and jacket assembly
   b. Cover assembly
   c. Charger assembly

2. Which action would you take to remove the barrel and jacket assembly?

   a. Depress buffer support lever
   *b. Pull back on disconnector for ring and rotate barrel jacket CW
   c. Pull back on both disconnector rings

3. After removing the barrel, which part would you remove next?

   a. Charger assembly
   *b. Cover assembly
   c. Firing trigger

4. After removing the cover, which part would you remove next?

   *a. Feed tray
   b. Cover latch rod
   c. Firing trigger

5. After removing the cover and feed tray, which part would you remove next?

   a. Charger assembly
   *b. Guide rod and spring assembly
   c. Backplate assembly

6. Which <u>two</u> actions would you take to remove the left guide rod and spring?

   a. Rotate left
   *b. Rotate right
   *c. Push in

7. After removing both guide rods and springs, which part would you remove next?

   a. Charger assembly
   b. Barrel extension assembly
   *c. Backplate assembly

* Indicates correct answer.

8. After removing the backplate, which part would you take action on next?

a. Buffer support lever
b. Cover latch rod
*c. Charger handle

9. Which action would you take to charge the weapon?

*a. Brace weapon while pulling back on charger handle
b. Depress buffer support lever while pulling charger handle
c. Push forward on barrel extension while pulling back on charger handle

10. With the barrel extension locked to the rear, which part would you take action on next?

*a. Buffer support lever
b. Right disconnector ring
c. Cover latch rod

11. Which action would you take to remove the barrel extension?

*a. Hold buffer support lever down and pull barrel extension to rear
b. Hold buffer support lever down and lift up on barrel extension
c. Hold buffer support lever down and push forward on barrel extension

12. Which <u>two</u> actions would you take to remove the breechblock?

a. Slide left
*b. Lift up
*c. Slide right

13. Which part would you remove next?

a. Front mounting screw
b. Charger handle screw
*c. Retaining clip

14. Which part would you remove next?

a. Front mounting stud
b. Left disconnector rign
*c. Rear mounting stud

M73 (MODEL 219) MACHINE GUN TEST QUESTIONS

ASSEMBLY

As the loader you have just cleaned and lubricated the M219 machine gun. Your task now is to assemble the weapon?

1. Which part would you install first?

   *a. Rear mounting stud
   b. Cover
   c. Charger assembly

2. After installing the rear mounting stud, which part would you install next?

   a. Cover and feed tray assembly
   *b. Charger assembly
   c. Backplate assembly

3. After installing the charger assembly, which part would you install next?

   *a. Breechblock
   b. Guide rods and springs
   c. Backplate assembly

4. Where in the receiver would you install the barrel extension?

   a. Front
   *b. Top rear
   c. Bottom rear

5. Which action would you take on the breechblock?

   a. Push forward
   *b. Slide to right
   c. Slide to left

6. Which part would you take action on next to install the barrel extension into the receiver?

   *a. Buffer support lever
   b. Cover latch rod
   c. Extractor

7. Which action would you take on the buffer support lever?

   a. Pull up
   *b. Push down
   c. Push forward

* Indicates correct answer.

8. How far into the receiver would you push the barrel extension?

a. Partially
b. Half-way
*c. Completely

9. After installing the barrel extension, which part would you install next?

*a. Backplate assembly
b. Cover
c. Guide rods and springs

10. After installing the backplate, which <u>two</u> actions would you take to install the left guide rod and spring?

*a. Rotate left
b. Rotate right
*c. Push in

11. Which picture shows the guide rods and springs properly installed?

*a. "V" is formed
b. "-/" is formed
c. "\-" is formed

12. Which part would you install next?

a. Cover
*b. Feedtray
c. Barrel

13. After installing the feed tray, which part would you install next?

*a. Cover
b. Barrel
c. Barrel jacket

14. If the cover fails to lock closed, which part would you take action on next?

a. Left disconnector ring
*b. Cover latch rod
c. Charger handle

15. Which part would you install next?

a. Receiver group
b. Barrel jacket
*c. Barrel

16. Which action would you take to install the barrel jacket assembly onto the receiver?

*a. Pull back on left disconnector ring and rotate barrel jacket assembly down
b. Depress buffer support lever and rotate barrel jacket assembly down
c. Push in on the cover latch rod and rotate barrel jacket assembly down

M73 (MODEL 219) MACHINE GUN TEST QUESTIONS

FUNCTION CHECK

After assembling the M219 machine gun, your next task as the loader is to conduct a function check.

1. Which part would you take action on first to conduct a function check?

   a. Cover latch rod
   *b. Safety
   c. Charger assembly

2. Which action would you take?

   *a. Slide lever to right
   b. Push lever up
   c. Slide lever to left

3. Which picture shows the result of that action?

   *a. "F" shows
   b. "S" shows

4. With the safety in FIRE, which part would you take action on next?

   a. Buffer support lever
   b. Cover
   *c. Charger handle

5. After hand charging the weapon, which part would you take action on next?

   a. Cover latch rod
   *b. Safety
   c. Charger assembly

6. Which picture shows where you would place the safety?

   a. "F" shows
   *b. "S" shows

7. With the safety in SAFE, which part would you take action on next?

   a. Buffer support lever
   *b. Trigger
   c. Charger handle

8. If the weapon does not fire, which part would you take action on next?

   a. Cover latch rod
   *b. Safety
   c. Charger handle

* Indicates correct answer

9. With the safety in FIRE, which action would you take next?

a. Press trigger
*b. Press trigger while holding charger handle rearward
c. Press trigger while pulling up on charger handle

10. Which part would you take action on next?

a. Cover latch rod
*b. Safety
c. Charger handle

11. Which picture shows the safety in the SAFE position?

a. "F" shows
*b. "S" shows

M73 (MODEL 219) MACHINE GUN TEST QUESTIONS

STOPPAGE

The M219 machine gun has fired more than 200 rounds within the past two minutes. The gunner announces "STOPPAGE". As the loader your task is to correct the stoppage.

1. Which action would you take first when applying immediate action to correct a stoppage?

   a. Slide safety to right
   b. Pull out the ammo belt
   *c. Wait for a hangfire

2. How long would you wait?

   a. Wait 1 second
   b. Wait 3 seconds
   *c. Wait 5 seconds

3. Which action would you take next?

   a. Pull out the ammo belt
   b. Slide safety to the left
   *c. Pull the charger handle fully rearward

4. After you announce "UP", the gunner attempts to fire and again announces "STOPPAGE". Which action would you take first?

   a. Slide safety to right
   b. Pull out the ammo belt
   *c. Wait for a hangfire

5. How long would you wait for a hangfire?

   a. Wait 1 second
   b. Wait 3 seconds
   *c. Wait 5 seconds

6. Which action would you take next?

   a. Pull out the ammo belt
   b. Slide safety to the left
   *c. Pull the charger handle fully rearward

7. After hand-charging the weapon, which part would you take action on next?

   a. Left disconnector ring
   b. Charger handle
   *c. Safety

* Indicates correct answer.

8. Which picture shows the result of that action?

a. "F" shows
*b. "S" shows

9. With the weapon charged and safed, which part would you take action on next?

a. Left disconnector ring
*b. Cover latch rod
c. Charger handle

10. After opening the cover, which part would you take action on next?

a. Buffer support lever
*b. Ammo belt
c. Charger handle

11. After removing the ammo belt and spent cartridges or links, which part would you take action on next?

a. Cover and feed tray
b. Charger handle
*c. Safety

12. Which action would you take to place the weapon in FIRE?

a. Push up
b. Slide to left
*c. Slide to right

13. Which part would you take action on next?

a. Cover
b. Trigger
*c. Charger handle

14. Which action would you take?

a. Press trigger while holding chain rearward
*b. Press trigger while slowly releasing charger handle
c. Press trigger

15. After pulling the charger handle to the rear, which part would you take action on next?

a. Cover and feed tray
*b. Safety
c. Charger handle

16. Which picture shows the result of that action?

   a. "F" shows
   *b. "S" shows

17. With the weapon safed, which action would you take next?

   *a. Reload the weapon
   b. Close the cover and feedtray
   c. Depress the buffer support lever

18. After reloading the weapon, which part would you take action on?

   *a. Cover
   b. Charger handle
   c. Trigger

19. Which part would you take action on next?

   a. Cover latch rod
   *b. Safety
   c. Charger handle

20. Which picture shows the end result of that action?

   *a. "F" shows
   b. "S" shows

M219 MACHINE GUN TEST

Answer Sheet

NAME_______________________________ UNIT_______________________

Practice Questions (Circle answer)

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D

FOR ADMINISTRATIVE USE

	ST Score					**HO Score**			
	CL	DI	AS	FC		CL	DI	AS	FC
PF	___	___	___	___	PF	___	___	___	___
ER	___	___	___	___	ER	___	___	___	___

TEST QUESTIONS

Clear	Disassemble	Assemble	Function Check	Stoppage
1. A B C D	1. A B C D	1. A B C D	1. A B C D	1. A B C D
2. A B C D	2. A B C D	2. A B C D	2. A B C D	2. A B C D
3. A B C D	3. A B C D	3. A B C D	3. A B C D	3. A B C D
4. A B C D	4. A B C D	4. A B C D	4. A B C D	4. A B C D
5. A B C D	5. A B C D	5. A B C D	5. A B C D	5. A B C D
6. A B C D	6. A B C D	6. A B C D	6. A B C D	6. A B C D
7. A B C D	7. A B C D	7. A B C D	7. A B C D	7. A B C D
8. A B C D	8. A B C D	8. A B C D	8. A B C D	8. A B C D
9. A B C D	9. A B C D	9. A B C D	9. A B C D	9. A B C D
10. A B C D	10. A B C D	10. A B C D	10. A B C D	10. A B C D
11. A B C D	11. A B C D	11. A B C D	11. A B C D	11. A B C D
12. A B C D	12. A B C D	12. A B C D		12. A B C D
13. A B C D	13. A B C D	13. A B C D		13. A B C D
14. A B C D	14. A B C D	14. A B C D		14. A B C D
15. A B C D		15. A B C D		15. A B C D
16. A B C D		16. A B C D		16. A B C D
17. A B C D				17. A B C D
18. A B C D				18. A B C D
19. A B C D				19. A B C D
20. A B C D				20. A B C D

PERFORMANCE CHECKLIST

TASK: CLEARING THE M219 MACHINE GUN

1	PLACE MG SAFETY IN FIRE POSITION					
	Slide trigger safety to left until "F" shows on backplate	P	T	L	A	R
2	HANDCHARGE THE MG					
	Grasp charger handle and pull fully rearward until bolt locks	P	T	L	A	R
3	PLACE MG SAFETY IN SAFE					
	Slide trigger safety to left until "S" shows on backplate	P	T	L	A	R
4	RAISE THE COVER ASSEMBLY					
	Push in on cover latch rod and hold momentarily	P	T	L	A	R
	Lift up on cover and rotate CW until fully opened	P	T	L	A	R
5	REMOVE AMMO BELT					
	Grasp ammo belt near receiver	P	T	L	A	R
	Pull out and up on ammo belt until removed	P	T	L	A	R
6	RAISE FEED TRAY GROUP					
	Lift up on feed tray and rotate fully CW	P	T	L	A	R
	*If locked, push the cover latch rod fully forward	P	T	L	A	R
	*Lift up on feed tray and rotate fully CW	P	T	L	A	R
7	INSPECT MG FOR AMMO					
	Insert finger into chamber (cold gun) and check for ammo	P	T	L	A	R
	Look into chamber for ammo	P	T	L	A	R
8	PLACE THE MG SAFETY IN FIRE POSITION					
	Slide trigger safety to left until "S" shows on backplate	P	T	L	A	R
9	"FIRE" THE MG					
	Pull the charger handle until chain is tightened	P	T	L	A	R
	Push manual firing trigger forward	P	T	L	A	R
	Release charger handle slowly until bolt is fully forward	P	T	L	A	R

* Indicates possible alternative actions required.

$\boxed{10}$ CLOSE FEED TRAY GROUP AND COVER ASSEMBLY	P	T	L	A	R
Rotate cover and feed tray down until locked in position	P	T	L	A	R
•If unlocked, push cover latch rod completely forward	P	T	L	A	R
•Push down on cover until it lockes in position	P	T	L	A	R
$\boxed{11}$ PLACE MG SAFETY IN SAFE					
Slide trigger safety to left until "S" shows on backplate	P	T	L	A	R

TASK: DISASSEMBLY OF M219 MACHINE GUN

1 REMOVE BARREL JACKET ASSEMBLY FROM RECEIVER

Pull left disconnector ring fully rearward	P	T	L	A	R
Rotate barrel jacket assembly CW until removed from receiver	P	T	L	A	R
*Pull left and right disconnector rings fully rearward	P	T	L	A	R
*Pull receiver assembly away from barrel jacket assembly	P	T	L	A	R

2 REMOVE BARREL FROM BARREL JACKET ASSEMBLY

Slide barrel rearward until removed from jacket assembly	P	T	L	A	R

3 REMOVE COVER ASSEMBLY

Push in on left cover latch rod and hold	P	T	L	A	R
Lift up on cover and hold	P	T	L	A	R
Push in on opposite cover latch rod	P	T	L	A	R
Lift off cover and place in safe position	P	T	L	A	R
*Push in on left and right cover latch rods and hold	P	T	L	A	R
*Tilt receiver on end and "drop" cover assembly	P	T	L	A	R

4 REMOVE FEED TRAY GROUP

Lift straight up on feed tray and place in safe position	P	T	L	A	R
*If locked, push cover latch rod completely forward	P	T	L	A	R
*Lift straight up on feed tray and place in safe position	P	T	L	A	R
*If still locked, push opposite cover latch rod forward	P	T	L	A	R
*Lift off feed tray and place in safe position	P	T	L	A	R

5 REMOVE LEFT GUIDE ROD AND SPRING ASSEMBLY

Insert tip of screwdriver into slot on left guide rod	P	T	L	A	R
Push in on guide rod to compress spring	P	T	L	A	R
Rotate guide rod CW/CCW until unlocked	P	T	L	A	R
Slowly let out the guide rod and spring until tension is released	P	T	L	A	R
Separate spring from guide rod	P	T	L	A	R

* Indicates possible alternative actions required.

6 REMOVE RIGHT GUIDE ROD AND SPRING ASSEMBLY

Insert tip of screwdriver into slot on right guide rod	P	T	L	A	R
Push in on guide rod to compress the spring	P	T	L	A	R
Rotate guide rod CW/CCW until unlocked	P	T	L	A	R
Slowly let out the guide rod and spring until tension is released	P	T	L	A	R
Separate spring from guide rod	P	T	L	A	R

7 REMOVE BACKPLATE ASSEMBLY

Grasp tip of manual firing trigger on backplate	P	T	L	A	R
Pull up on trigger until backplate is removed from receiver	P	T	L	A	R

8 REMOVE BARREL EXTENSION ASSEMBLY

Brace the MG near front of receiver group	P	T	L	A	R
Grasp charger handle and pull bolt completely rearward	P	T	L	A	R
Depress the buffer support lever and hold	P	T	L	A	R
Slide the barrel extension rearward until removed from receiver	P	T	L	A	R

9 REMOVE BREECHBLOCK FROM BARREL EXTENSION

Slide breechblock left to center position and lift up and out	P	T	L	A	R

10 REMOVE CHARGER ASSEMBLY

Insert screwdriver under "C" ring	P	T	L	A	R
Pry off "C" ring from rear mounting stud	P	T	L	A	R
Pull assembly away from studs and lift off	P	T	L	A	R

11 REMOVE CHARGER MOUNTING STUD

Slide stud fully forward and lift out	P	T	L	A	R

TASK: ASSEMBLY OF M219 MACHINE GUN

1	INSTALL CHARGER MOUNTING STUD					
	Place circle end of stud onto rail in slot below cover latch rod	P	T	L	A	R
	Slide mounting stud fully rearward	P	T	L	A	R
2	INSTALL CHARGER ASSEMBLY					
	Hook half-moon cut of assembly onto buffer pivot pin	P	T	L	A	R
	Insert hole at opposite end of assembly onto charger mounting stud	P	T	L	A	R
	Insert open end of "C" clip between charger mounting stud and assembly	P	T	L	A	R
	Slide retaining clip up onto stud until locked	P	T	L	A	R
3	INSTALL BREECHBLOCK INTO BARREL EXTENSION					
	Align left top edge of breechblock with center of barrel extension camways	P	T	L	A	R
	Lower into camways and slide fully to right edge of extension	P	T	L	A	R
4	INSTALL BARREL EXTENSION ASSEMBLY INTO RECEIVER					
	Align the front of assembly with top-rear edge of receiver	P	T	L	A	R
	Place grooved edges of assembly onto rails at receiver and and slide slightly forward	P	T	L	A	R
	Slide breechblock completely to the right of extension	P	T	L	A	R
	Depress buffer support lever and hold	P	T	L	A	R
	Push fully forward on assembly until it locks in receiver	P	T	L	A	R
5	INSTALL BACKPLATE ASSEMBLY					
	Align bottom edge of backplate with top rear of receiver	P	T	L	A	R
	Place grooved edge of backplate with top rear of receiver and slide fully down	P	T	L	A	R

6 INSTALL LEFT GUIDE ROD AND SPRING ASSEMBLY

Insert guide rod spring through hole on left side of backplate	P	T	L	A	R
Insert guide rod through spring in backplate	P	T	L	A	R
*Insert guide rod into spring and slide into hole on left side of backplate	P	T	L	A	R
Insert tip of screwdriver into slot on guide rod	P	T	L	A	R
Push guide rod completely forward and rotate CW/CCW until locked in position (left side of "V" is formed)	P	T	L	A	R

7 INSTALL RIGHT GUIDE ROD AND SPRING ASSEMBLY

Insert guide rod spring through hole on right side of backplate	P	T	L	A	R
Insert guide rod through spring in backplate	P	T	L	A	R
*Insert guide rod into spring and slide into hole on right side of backplate					
Insert tip of screwdriver into slot on guide rod	P	T	L	A	R
Push guide rod completely forward and rotate CW/CCW until locked in position (right side of "V" is formed)	P	T	L	A	R

8 INSTALL FEED TRAY GROUP

Align left side of feed tray with center brackets at top edge of receiver	P	T	L	A	R
Insert feedtray "hinges" onto cover latch rod until seated	P	T	L	A	R
*If not seated, push in on cover latch rod until it locks forward	P	T	L	A	R
*Insert feed tray "hinges" onto cover latch rod until seated	P	T	L	A	R

9 INSTALL COVER ASSEMBLY

Align left side of cover with outer brackets at top edges of receiver	P	T	L	A	R
Insert "hinges" on cover onto cover latch rods and depress until locked	P	T	L	A	R
*If not locked, push in on cover latch rod until it locks forward	P	T	L	A	R

* Indicates possible alterantive actions required.

$\boxed{10}$ INSTALL BARREL INTO BARREL JACKET ASSEMBLY

Insert front of barrel into rear of jacket assembly and slide forward	P	T	L	A	R
Rotate barrel until "locator" is aligned with barrel jacket	P	T	L	A	R
Slide barrel (and locator) fully forward into jacket assembly	P	T	L	A	R

$\boxed{11}$ INSTALL BARREL JACKET ASSEMBLY ONTO RECEIVER

Insert right connector of barrel jacket onto right mounting stud	P	T	L	A	R
Pull back on left disconnector ring and hold	P	T	L	A	R
Rotate barrel jacket assembly completely CCW	P	T	L	A	R
Release disconnector ring to lock barrel jacket assembly	P	T	L	A	R
*Align connector holes on barrel jacket assembly with mounting studs	P	T	L	A	R
*Snap barrel jacket assembly onto receiver until it locks	P	T	L	A	R

TASK: CONDUCT A FUNCTION CHECK

1 PLACE THE MG SAFETY IN FIRE POSITION

Slide trigger safety to left until "F" shows on backplate	P	T	L	A	R

2 HANDCHARGE THE MG

Grasp charger handle and pull fully rearward until bolt locks	P	T	L	A	R

3 PLACE MG SAFETY IN SAFE POSITION

Slide trigger safety to left until "S" shows on backplate	P	T	L	A	R

4 "FIRE" THE MG

Push manual firing trigger forward	P	T	L	A	R

5 PLACE THE MG SAFETY IN FIRE POSITION

Slide trigger safety to left until "F" shows on backplate	P	T	L	A	R

6 "FIRE" THE MG

Pull the charger handle until chain is tightened	P	T	L	A	R
Push manual firing trigger forward	P	T	L	A	R
Release charger handle slowly until bolt is fully forward	P	T	L	A	R

7 PLACE MG SAFETY IN SAFE

Slide trigger safety to left until "S" shows on backplate	P	T	L	A	R

TASK: APPLYING IMMEDIATE ACTION ON A M219 MACHINE GUN STOPPAGE

1	WAIT FOR HANGFIRE					
	Wait 5 seconds for weapon stoppage to clear	P	T	L	A	R
2	HANDCHARGE THE MG					
	Grasp charger handle and pull fully rearward until bolt locks	P	T	L	A	R
3	ISSUE FIRE COMMAND ELEMENT					
	Announce "UP"	P	T	L	A	R
4	WAIT FOR HANGFIRE/COOKOFF					
	Wait 5 seconds for weapon stoppage to clear	P	T	L	A	R
5	HANDCHARGE THE MG					
	Grasp charger handle and pull fully rearward until bolt locks	P	T	L	A	R
6	PLACE MG SAFETY IN SAFE POSITION					
	Slide trigger safety to left until "S" shows on backplate	P	T	L	A	R
7	RAISE THE COVER ASSEMBLY					
	Push in on cover latch rod and hold momentarily	P	T	L	A	R
	Lift up on cover and rotate CW until fully open	P	T	L	A	R
8	REMOVE AMMO BELT					
	Grasp ammo belt near receiver	P	T	L	A	R
	Pull out and up on belt until removed	P	T	L	A	R
9	RAISE THE FEED TRAY GROUP					
	Lift up on feed tray and rotate fully CW until open	P	T	L	A	R
	*If locked, push the cover latch rod fully forward	P	T	L	A	R
	*Lift up on feed tray and rotate fully CW until open	P	T	L	A	R
10	CLEAR MG OF AMMO/OBSTRUCTION					
	Remove live or spent cartridges/links from MG	P	T	L	A	R

*Indicates possible alternative actions required

11 PLACE MG SAFETY IN FIRE POSITION

Slide trigger safety to right until "F" shows on backplate	P	T	L	A	R

12 HAND FUNCTION THE MG

Hold charger handle fully rearward	P	T	L	A	R
Depress the manual firing trigger	P	T	L	A	R
Release charger handle slowly until bolt is fully forward	P	T	L	A	R
Grasp charger handle and pull back until bolt locks to the rear	P	T	L	A	R

13 PLACE MG SAFETY IN SAFE POSITION

Slide trigger safety to left until "S" shows on backplate	P	T	L	A	R

14 LOWER THE FEED TRAY GROUP

Rotate feed tray down until it locks in position	P	T	L	A	R
*If unlocked, push the cover latch rod fully forward	P	T	L	A	R
*Push down on feed tray until it locks in position	P	T	L	A	R

15 LOAD THE MG

Place ammo belt in feed tray	P	T	L	A	R
Slide ammo belt to feed slot	P	T	L	A	R
Hold ammo in place	P	T	L	A	R
Rotate the cover down until it locks in position	P	T	L	A	R

16 PLACE THE MG SAFETY IN FIRE POSITION

Slide trigger safety to right until "F" shows on backplate	P	T	L	A	R

17 ISSUE FIRE COMMAND ELEMENT

Announce "UP" and observe MG firing	P	T	L	A	R

Table H-1

Relationship Between HO Test Performance and Prior AVS Test Performance on Coaxial Machine Gun (M73/219) Tasks

Task	HO Test Performance		Combined HO Test Performance	
	Fail	Pass	Fail	Pass
Clearning				
AVS Pass	0	3		
Borderline[1]	0	2		
AVS Fail	5	7		
Disassembly				
AVS Pass	1	9	0	2
Borderline[1]	1	2	0	4
AVS Fail	2	2	7	7
Assembly				
AVS Pass	0	14		
Borderline[1]	1	2		
AVS Fail	0	0		
Function Check				
AVS Pass	0	13	0	13
Borderline[1]	0	0	0	2
AVS Fail	1	3	1	1
Stoppage				
AVS Pass	0	7		
Borderline[1]	1	4		
AVS Fail	2	3		

[1] One AVS test error in Borderline group for individual HO tests, or one-two errors for combined tests.